FEB 2 1924

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

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TUTORS, 254, Oxford Road, Manchester. Estab. 1876. Enrol now for I.C.E. and I.M.E. Postal Courses. 100 per cent. passes last Exams. Reinforced Concrete—a new comprehensive course under expert engineer, £3 3s. Write for particulars. 1711

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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817

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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 75.

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FEED WATER HEATERS,
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See Advertisement, page 100. 1872

Machinery, Plant, &c.

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SIX VERTICAL COCHRAN BOILERS, 14 ft. 6 in. by 6 ft. 6 in., 150 lbs. working pressure.

Large stock of second-hand FLAT ENDED CIRCULAR BOILER STORAGE TANKS.

21 CLOSED TOP TANKS, each 9 ft. 9 in. by 5 ft. 0 in. by 4 ft. 0 in. deep, plates ¼ in. thick, capacity about 1218 gallons, with opening in top 5 ft. 0 in. by 3 ft. 9 in.

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LANCASHIRE BOILER, 17 ft. by 5 ft. 6 in. diameter, reinsure 80 lbs. pressure.

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POWERFUL DOUBLE GEARED BORING MACHINE, by J. Hetherington & Sons, spindle 6 in. diam., with tapping motion, table 10 ft. 6 in. by 10 ft. 6 in.

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One 9 ft. UNDER DRIVEN MORTAR MILL, with false bottom, etc.

One PRACTICALLY NEW BRICK MAKING MACHINE, by Wm. Boulton, with one pair of tollers, and pug mill underneath.

3-ton, 55 cwt., 3 cwt., WEIGHING MACHINES.

Overhead three-motor ELECTRIC TRAVELLING CRANES, suitable for 440 volt continuous current.

Several 5-ton varying from 23 ft. to 38 ft. 2 in. span.

Two 2-ton, span 20 ft.

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One-ton ELECTRIC TRAVELLING UNDERHUNG JIB CRANES, 20 ft. 7½ in. All the above are in good condition, can be inspected on gantries in operation.

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STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

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LIMITED.
See Advertisement page 60, Jan. 11. 2402

Matthew Paul & Co., Ltd.,
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Taylor & Challen
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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works, and Showrooms: BIRMINGHAM.
See advert., page 80, Jan. 4. 3196

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NEWBURY, ENGLAND. 1631

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54 & 55, FETTER LANE, LONDON, E.C. 4,
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and Principal Provincial Cities and Abroad.

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CELITE PRODUCTS CORPORATION, Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, Jan. 11.

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Make it of
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The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

PATENTS AND DESIGNS ACTS, 1907 and 1919.

Notice is Hereby Given that

AARON JACOB ISRAEL of "Moresby," 40, St. John's Road, Houghton Estate, Johannesburg, Transvaal, Province of the Union of South Africa, seeks leave to amend the specification of Letters Patent No. 146346 granted to him for "Process of Lining Metal Pipes and the like."

Particulars of the proposed amendment were set forth in the Illustrated Official Journal (Patents), issued on the 9th January 1924.

Any person, or persons, may give notice of Opposition to the Amendment by leaving Patents Form No. 19 at the Patent Office, 25, Southampton Buildings, London, W.C.2, within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS,
Comptroller-General. C647

Correspondence Courses for

Inst.C.E., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc., Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1296

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 233, Oxford Road, Manchester. 1879

TENDERS.

THE MINISTRY OF PUBLIC WORKS, EGYPT, is calling for

Tenders for the Supply and

ERECTION of a PUMPING PLANT at Bonelli.

The contract will include the supply, delivery and erection of the whole of the Machinery and Accessories, including Four Internal Combustion Engines each directly coupled to Centrifugal or Turbine Pump.

Forms of Tender and Specification, price 10/-, can be obtained at the Office of THE INSPECTING ENGINEER, Egyptian and Sudan Governments, Queen Anne's Chambers, Westminster, S.W.1.

Tenders must be sent direct to Cairo, to reach there not later than Noon on the 31st March, 1924. C 650

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for :—

NINE SPANS, DECK SPAN GIRDER BRIDGES, 60 FEET SPANS.
SIX SPANS, DECK SPAN GIRDER BRIDGES, 40 FEET SPANS.

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, E.C.2, on or after 14th January, 1924.

A fee of 20/- will be charged for the Specification, which is NOT returnable.

Tenders must be submitted not later than NOON on Monday, 28th January, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. C. VOLKERS,
Secretary. C 649

HWART AND COLLIS LIMITED.
(In Voluntary Liquidation.)

The Assets of the above

Company other than the shareholding in Hwart & Son Limited, are FOR SALE and OFFERS for them are INVITED.

The Freehold Land (about 7½ acres), having a frontage of approximately 650 feet on the Hanworth Road, Sunbury Common, Middlesex, Buildings situated thereon, Plant, Machinery, Motor Lorries, Stock and Goodwill are included in the Assets now offered, and an approximate Schedule and an order to view can be obtained on application to the Liquidator—

SIR WILLIAM HENRY PEAT, K.B.E.,
11, Ironmonger Lane, E.C.,

to whom all offers should be submitted on or before 18th February, 1924. C 668

ADMINISTRATIVE COUNTY OF LONDON.

TWIN SCREW STEAMSHIP.

The London County Council invites

Tenders for the Construction

and DELIVERY of a TWIN SCREW STEAMSHIP, about 260 ft. long by 43 ft. beam, with machinery, etc., for the conveyance of 1500 tons of sewage sludge from the Outfall Works at Crossness and Barking Creek to the North Sea.

Persons desiring to submit Tenders may obtain on and after Monday 21st January, 1924, the Drawings, Specification, Form of Tender, etc., on application to the Chief Engineer, at the Old County Hall, Spring Gardens, S.W.1, upon payment of the sum of £5. This amount will be returnable only if a *bona fide* Tender is submitted and not subsequently withdrawn. Full particulars may be obtained on personal application, and the drawings, specification and other contract documents may be inspected at the Old County Hall before payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E.1, after Four p.m. on Monday, 11th February, 1924, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council. C 677

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, COPTHALL AVENUE, LONDON, E.C.2, invite

Tenders for :—

1. SHEFFIELD TOOLS, etc. ... ... Fee 5/-
2. RAILWAY TICKETS ... ... ,, 7/6

Tenders are due by Eleven a.m. on 29th January, 1924. Tender forms obtainable at above address. FEES NOT RETURNABLE. C 685

EGYPTIAN STATE RAILWAYS.

Tenders are Required for the

CONSTRUCTION of STEEL ROOFS and SHELTER of Alexandria New Station.

Copies of the Specification and Drawings may be obtained from the INSPECTING ENGINEER, Egyptian and Sudan Governments, Queen Anne's Chambers, Broadway, Westminster, S.W., on payment of £6 3s. 0d.

Tenders are to be submitted to the Authorities in Cairo not later than the 1st May, 1924. C 690

THE CORNWALL COUNTY COUNCIL invites

Tenders for the Construction

of a LARGE STEAM CHAIN FLOATING BRIDGE for use on its Ferry Service between Devonport and Torpoint.

Copies of the Drawings and Specification, and a Form of Tender may be obtained from the undersigned on payment of Two Guineas, which will be returned on receipt of a *bona-fide* Tender, and, if the Tender is not accepted, on the return of all papers and documents.

Sealed Tenders, endorsed "Floating Bridge," should be received by the undersigned not later than Ten a.m. on Tuesday, the 12th February, 1924.

The Council does not bind itself to accept the lowest or any Tender.

W. L. PLATTS,
Clerk of the County Council.

County Hall, Truro,
15th January, 1924. C 672

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of :—

POINTS AND CROSSINGS, ETC.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked :—"Tender for Points and Crossings, etc.," must be left with the undersigned not later than Twelve noon on Friday, the 8th February, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10/- for each copy of the Specification.

Copies of the drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

W. B. REYNOLDS,
for Managing Director.

11th January, 1924.
91, Petty France, S.W.1. C 654

CITY OF MANCHESTER.

BARTON POWER STATION.

The ELECTRICITY COMMITTEE of the MANCHESTER CORPORATION are prepared to receive

Tenders for :—

ONE LOCOMOTIVE JIB CRANE AND GRAB.

Specification and Form of Tender may be had on application to Mr. C. Cradock, Committee Secretary, Electricity Department, Town Hall, Manchester, on payment of a fee of One Guinea, which amount will be refunded on receipt of a *bona-fide* Tender.

Further particulars and information can be obtained on application to Mr. S. L. Pearce, Chief Engineer and Manager, Dickinson Street, Manchester.

Tenders, duly endorsed and addressed to the Chairman of the Electricity Committee, must be delivered at the Town Hall not later than Ten a.m. on Monday, 4th February, 1924.

The Firm entrusted with the work will be required to enter into a contract to be prepared by the undersigned.

The Corporation do not bind themselves to accept the lowest or any Tender.

P. M. HEATH,
Town Clerk.

Town Hall, Manchester,
14th January, 1924. C 663

COUNTY BOROUGH OF STOKE-ON-TRENT.
ELECTRICITY DEPARTMENT.

The Corporation invite

Tenders for the Supply of the

undermentioned PLANT, SWITCHGEAR and TRANSFORMERS.

H.T. Single-phase Ironclad Switchgear. (Contract 2315/S.)
Coal Bunkers and Conveying Plant. (Contract 2401/P.)
H.H.T. Ironclad Switchgear. (Contract 2402/S.)
H.H.T. Truck-type substation Switchgear. (Contract 2403/S.S.)
Static Transformers. (Contract 2404/T.)

Tender Forms and Specifications obtainable from Borough Electrical Engineer, St. Peter's Chambers, Stoke-on-Trent, on deposit of £2.

Tenders to be delivered by Noon, February 13th, 1924, to

R. B. SHARPLEY,
Town Clerk.

Town Hall, Stoke-on-Trent.
10th January, 1924. C 652

APPOINTMENTS OPEN.

Wanted, Engineer to take

charge of Stand at Wembley Exhibition for important North Country Heavy Engineering Firm. Applicants should have commercial experience and good technical knowledge of Steam and Oil Prime Movers.—Address, stating age, experience and salary required, C 683, Offices of ENGINEERING.

FINSBURY TECHNICAL COLLEGE.

A Chief Assistant of Graduate

rank and with works experience is REQUIRED in the Electrical Engineering Department to take up duty at the end of February. Salary will be in accordance with the scale adopted by the London County Council.—Applications to be addressed to Dr. W. H. ECCLES, at the College, Leonard Street, E.C., and received not later than the 31st January, 1924. C 648

Manager Wanted to take

charge of Shops in large Ship Repairing Establishment, must be thoroughly practical, good organizer, and have substantial experience of up-to-date practice where shops embody all classes of work including foundry. State clearly, experience, age and salary expected.—Address, C 619, Offices of ENGINEERING.

Manager Wanted for

Important Industrial, Engineering and Constructional Concern. Must be thoroughly competent organiser, familiar with coal, gas and fuel oil business.—Apply, by letter, BOX 431, DORLAND AGENCY, 16, Regent Street, S.W.1. C 606

Assistant Works Manager,

with good organising ability, mechanical knowledge, and previous managerial experience REQUIRED by large Firm of Rolling Stock Engineers.

All round knowledge of Steel and Wood construction necessary.

Good salary to right man.—Address, C 638, Offices of ENGINEERING.

Melting Shop Manager

WANTED. Thoroughly experienced in both Acid and Basic Processes of Steel-making with cold and hot metal in a modern Plant.—Apply, stating age, experience, qualifications and salary expected, to the SECRETARY, THE CONSETT IRON COMPANY, Ltd., Consett, Co. Durham. C 640

Assistant Manager Wanted

for Marine Engineering Works in China. Applicants must possess thorough technical and also practical knowledge of modern Marine Engineering. Age 35 to 40. Salary commencing £750.

Address, detailing experience and qualifications for the post, C 524, Offices of ENGINEERING.

Engineer Wanted, to Take

control of the shops under the Managing Director.

Applications only desired from those having the highest qualifications and experience in the maintenance, and output of a Machine Tool Shop.

State age, experience, and salary required.—Address, C 592, Offices of ENGINEERING.

MERTON AND MORDEN URBAN DISTRICT COUNCIL.

TEMPORARY CIVIL ENGINEERING ASSISTANT.

Applications are Invited for

the APPOINTMENT of a Fully Qualified TEMPORARY CIVIL ENGINEERING ASSISTANT.

Applicants must have had extensive practical experience in the design and construction of Large Main Sewers of Reinforced Concrete and Brickwork, and must be expert Surveyors and Levellers, good Draughtsmen and capable of preparing specifications and quantities.

Preference will be given to applicants who have qualified (by examination) for the Institution of Civil Engineers or Municipal and County Engineers.

The appointment will be for six months certain with a possible extension beyond that time. Applications stating age, qualifications and experience, salary required and accompanied by copies of three recent testimonials, must reach the undersigned not later than Four p.m. on Tuesday, the 29th January, 1924.

C. J. MOUNTIFIELD,
Clerk to the Council.

District Council Offices,
Kingston Road,
Merton, S.W. 19.
17th Jan., 1924. C 695

Civil Engineer.—Assistant

REQUIRED for Railway Engineer's Office. Applicants should be Associate Members of the Institution of Civil Engineers, or hold equivalent professional qualifications. Experience in all branches of Railway Engineering, including Structural Design, and ability to turn out neat and reliable work expeditiously, is essential. Applicants should give full particulars of qualifications and experience, age, and salary required.—No. 462, KEITH & Co., Advertising Agents, Edinburgh. C 660

Wanted, Highly-skilled

TOOLMAKER-MECHANIC, capable of getting results, as second man in charge small works near Brighton. £3 10s. week, plus 5 per cent. firm's nett profits. Applications useless without two testimonials certifying skill as toolmaker. Capital employed £12,000. Unlimited scope in world's markets.—Address, C 656, Offices of ENGINEERING.

The Royal Air Force

REQUIRES ELECTRICAL FITTERS, FITTERS ARMO ENGINE, FITTERS DRIVER PETROL, FITTERS GENERAL, WIRELESS OPERATORS and POWER STATION TRADESMEN. Age limits :—Ex-Service men 18 to 30; Non Ex-Service 18 to 26; men highly skilled in certain trades up to 35; ex-N.C.Os. up to 38 (with rank according to trade ability). Pay from 24/6d. to 66/6d. per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call:—INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, London, W.C.2. C 485

Chief Draughtsman Required,

thoroughly experienced in Aerial Ropeways. State details of experience, age and salary required. Also Good DRAUGHTSMAN, experienced, same class of work.—Address, C 67?, Offices of ENGINEERING.

Designer for Reinforced CONCRETE.

WANTED, fully Qualified MAN with wide experience in design, and details of R. C. Structures.

Applications to be made in writing, giving full information as to experience, qualifications, age and salary required, addressed to THE CHIEF ENGINEER, THE GAS LIGHT & COKE COMPANY, Horseferry Road, London, S.W.1. C 631

Heating Draughtsman

REQUIRED, fully experienced, capable of scheming and estimating.—State age, experience, and salary required to "THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LTD., 17, Summer Row, Birmingham. C 634

Required Immediately

DRAUGHTSMAN, with knowledge of electricity for commercial vehicle work. State experience and salary required.—TILLING-STEVENS MOTORS LIMITED, Maidstone. C 681

First-class Draughtsman

REQUIRED for Reinforced Concrete Specialists Firm. State salary required and age. Write BOX 1621, c/o BROWN'S, 39, Tothill St., Westminster. C 668

Thoroughly Experienced

DRAUGHTSMAN WANTED. Refrigeration practice essential. Letter only, fullest particulars. —WEST-BEYNON, 82, Belvedere Rd., S.E.1. C 669

Boiler Shop Foreman Required

by Firm specialising in the manufacture of Vertical and Marine type Boilers. Applicants must have held similar position previously and have sound experience with above types of boilers.—Address, stating age, salary required and references, C 647, Offices of ENGINEERING.

SITUATIONS WANTED.

Naval Officer, Engineer-

Captain retired, age 48, strong, active, SEEKS POSITION Engineering, Secretarial, Travelling, or any position of Trust. Highest references. Go anywhere at home or abroad. Small remuneration only desired.—BOX 601, c/o WILLS, LTD., 300, High Holborn, W.C.1. C 633

Engineer, 43, M.I.A.E., Wide

Experience design, construction operation automobile and aircraft engines; smaller classes marine petrol, oil and steam machinery; small lighting plants; technical writing, DESIRES APPOINTMENT, British Empire Exhibition or otherwise.—Address, C 675, Offices of ENGINEERING.

Engineer, First-class B.O.T.

Certificate, 25 years' sea experience, DESIRES POSITION on Steamer, Home or Abroad. Have sailed as Chief-Second on Cargo and Tank Steamers, also 14 months' with Internal Combustion Engines. References.—Address, C 674, Offices of ENGINEERING.

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30,000 K.W. STEAM TURBO-GENERATOR AT ROTHERHAM.

THE most remarkable development of any electrical undertaking in this country is that effected at Rotherham by Mr. Edward Cross, electrical engineer to the corporation. When the war broke out the plant installed had a rated capacity of but 4,500 kw. Then, however, a rush of war orders came to the local factories, and an insistent demand for more power. This was met at the outset by installing two new units of 5,500 kw. each, thus more than trebling the original capacity of the station. This large addition, however, failed to satisfy the demand from the factories engaged on war work, and as a consequence a new station was constructed in which were erected two 12,500-kw. machines built for Melbourne by Messrs. C. A. Parsons and Co. In view of the impossibility of ensuring a safe delivery of these machines in Australia, and the pressing needs of Rotherham, these units were commandeered by the Government and installed as described. The demand continued to grow, however, and early in 1918 a contract was entered into, with the British Thomson-Houston Company, of Rugby, for the 30,000-kw. turbo-generator, of which we give illustrations on Plate III. and on the present page, and pages 66 and 67.

This machine is the largest yet constructed in this country, and one of the largest in the world to develop its power in a single casing. It was built at the company's Rugby works and is of their multi-stage impulse type, the characteristic feature of which is the use of wheels of small diameter at the high-pressure end. This involves, of course, a greater number of stages than when the wheels are all of the same diameter, but the arrangement tends to keep down both the disc friction losses and the loss by leakage through the diaphragm packings. In the present case the total rotation losses are about 1 per cent. when the output is 25,000 kw., and a little less at maximum load. In short, at this maximum load the total "parasitic" losses amount to but little over 2 per cent., so that the ratio of shaft kilowatts to "indicated" kilowatts is nearly 98 per cent., and since the generator efficiency is 97 per cent. the kilowatts at the switchboard amount to nearly 95 per cent. of the "indicated" output.

The unit has a rated capacity of 30,000 kw., and is designed to run at 1,500 r.p.m. The generator is wound to carry its full rated load at a power factor of 75 per cent., the current being three-phase 50-cycles at a pressure of 6,600 volts. The turbine was designed to work with steam supplied to the stop valve at a gauge pressure of 200 lb. per square inch, and at a temperature of 588 deg. F., the vacuum being 28½ in., and with this the following guarantees were given :—

Output in kilowatts ...	30,000	25,000	20,000	15,000
Steam rate, lb. per kw.-hour	11·4	11·1	11·4	12·0

The subjoined table gives the results obtained during tests with water resistances.

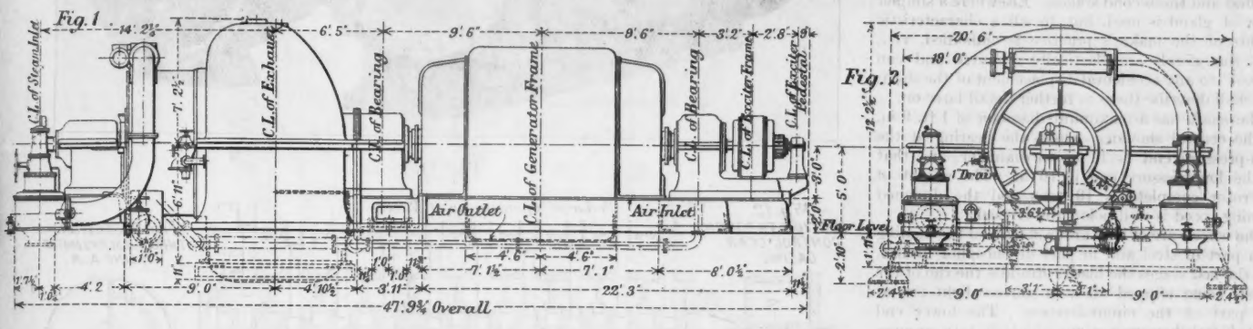
In the third trial there is a slight discrepancy between the stop valve pressure and that in the lower steam chest. Both gauges were certified by the National Physical Laboratory, and the small inconsistency is perhaps due to some local eddy, which with the enormous volume of steam being passed in this test became strong enough to be detectable. All instruments used were specially calibrated both before and after the test, and it is very noteworthy, as indicating the certainty with which steam consumption can now be estimated beforehand, that at 25,000 kw., which was originally intended to be the most economical rating, the guaranteed and calculated figures are in practically perfect agreement. At the overload, however, the consumption under test instead of being higher than at 25,000 kw. is actually less. This has, however, arisen from modifications made in the governor valve arrangements originally contemplated. The overload is now taken without the use of a by-pass, and under these conditions the maximum output is now that corresponding to maximum efficiency. The steam rate is in fact very nearly uniform over a large range of load, which is due mainly to the circumstance that at all outputs over half-load the governing is effected by opening or closing nozzle valves, of which no less than 10 are provided. Hence, at the worst, the steam is wire drawn at one of these 10 valves only, whilst the others are all running full bore.

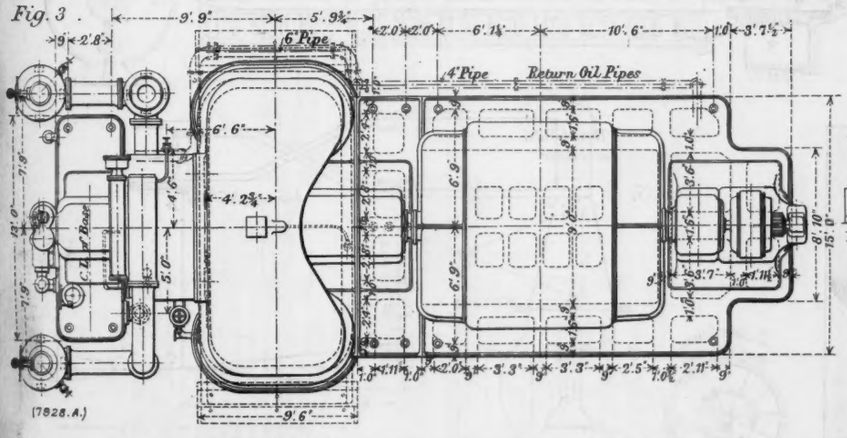
Under test the unit developed 31,000 kw. or over 40,000 h.p. A reference to Figs. 1 and 2 shows that the extreme overall dimensions of the unit are 47 ft. 9¾ in. length, 19 ft. in breadth by 12 ft. 2½ in. above floor level. The turbine, it will be seen, occupies less than one-half the total length of the unit. Its total weight including valves is 170 tons, or about 8·9 lb. per brake horse-power at the turbine shaft. The steam supply is nearly 350,000 lb. per hour, and it was accordingly considered best to fit two stop valves in parallel, thus keeping down to more moderate dimensions the steam way required at each valve. These stop valves are indicated in Figs. 6 to 8 by *a*. That shown to the left in Fig. 6 is coupled up to a governor valve shown at *b*, Figs. 7 and 8, and through this valve are supplied those first-stage nozzles which are fixed in the lower half of the casing. Up to half-load the turbine takes the whole of its steam supply through this throttle governor valve. The other stop valve communicates with a valve-box *c*, Fig. 5, mounted on the upper half of the turbine casing. In this valve-box are 10 valves through which the steam is supplied to nozzles in the upper half of the casing. A servo-motor, which we will describe in detail later on, opens these nozzles in succession as the load increases beyond the half-load limit, and between this and the maximum load the whole of the governing is effected by opening or closing these nozzle valves.

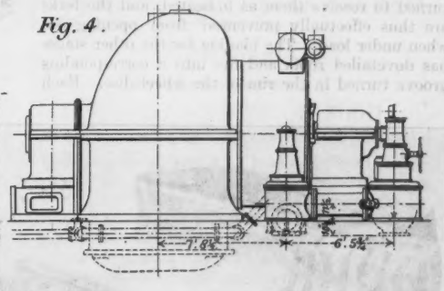
A longitudinal section through the turbine is represented in Fig. 5, Plate III. There are, it will be seen, 14 stages in all. The smallest wheel has a mean diameter of 62 in., and the largest a mean diameter of 9 ft. 10 in. The external diameter in this case is 11 ft. 8 in., so that the peripheral speed at this last stage is about 918 ft. per second. At maximum load and with a 28½ in. vacuum the "leaving" loss is of the order of 1¼ per cent. of the adiabatic heat drop.

The plan of using wheels of small diameter at the

Load in kilowatts ..	16,071	25,965	31,287	21,235
Stop valves in use ..	Left hand only	Both	Both	Right hand only
Stop valve pressure, lb. per sq. in. (gauge) ..	203·45	200·6	195·8	211·6
Temperature stop valve, deg. F.	583·5	639·15	647·6	639·6
Vacuum corrected to 30-in. barometer, inches ..	28·47	28·05	27·657	28·46
Net condensate weighed, lb. per hour	191,937	288,707	351,374	233,302
Uncorrected water rate, lb. per kw.-hour ..	11·94	11·12	11·23	10·99
Water rate, lb. per kw.-hour, corrected to 200 lb. per sq. in. (gauge), 200 deg. F. superheat and 28½-in. vacuum ..	11·89	11·19	11·05	11·42
Pressure in lower steam chest, lb. per sq. in. (gauge)	170·7	193·3	197·3	—
Pressure in first compartment, lb. per sq. in. (gauge)	65·2	113·0	144·3	85·5







high pressure end has, as already mentioned, the advantage of making the rotation loss less than is commercially practicable if all the wheels are made of the same mean diameter. In the present case the rotation losses at maximum load amount to about 0·8 per cent. The leakage losses at the diaphragms are also minimised by this plan, and amount in fact to not more than 1 per cent. The total parasitic losses (exclusive of the leaving loss, which comes under a different category) are accordingly very low, as already stated.

As shown, a two-row velocity compounded wheel is used for the first stage. It has a mean diameter of 66½ in. At maximum load the admission extends over about two-thirds of the total circumference of this wheel, but the idle sections are shielded, thus eliminating losses due to fan action.

The pressure in the first compartment is 138 lb. per square inch gauge at maximum load, and to reduce leakage losses it will be seen that an exceptionally long gland has been provided between the first and the second stages. Elsewhere a simpler form of gland is used, but in all a characteristic feature of the maker's practice is embodied, viz., that the glands are elastically mounted and can "give" to any accidental displacement of the shaft. We shall describe these in further detail later on.

The shaft has a maximum diameter of 1 ft. 9 in. at the central shoulder, whilst the bearing at the high-pressure end is 14 in. in diameter, and that at the low-pressure end is 16 in. The weight of the rotor complete is 19 tons and the designed running speed is well below the critical.

The wheels are of high grade steel, and the blading is in part of steel and in part of phosphor bronze. For the last stages the blades straddle the rim of the wheel, being slipped on at a narrow light cut at one part of the circumference. The lower end of each fork has projections which fit into grooves turned to receive them as indicated, and the forks are thus effectually prevented from opening out when under load. The blading for the other stages has dovetailed roots and fits into a corresponding groove turned in the rim of the wheel disc. Each

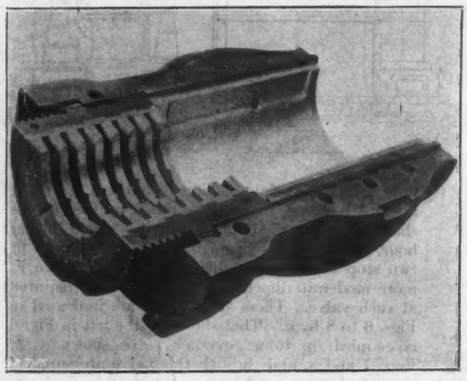


FIG. 14.

wheel is provided at the bore with two bronze rings, which protrude slightly, and these form the bearing between the wheels and the shaft. With this arrangement there is no possibility of the wheel and shaft rusting up solid. Each of the first six wheels is fitted with three keys, whilst the remaining wheels have one. The dotted lines shown near the central portion of the wheels represent screwed holes, by means of which the wheels can be readily withdrawn should this unlikely necessity arise.

The diaphragms are mostly of cast-iron, and they are fitted at their inner periphery with the elastic packing to which reference has already been made.

The high pressure end of the casing is built up of steel castings, but as the superheat disappears under normal conditions at or about the ninth stage, it has been possible to use cast-iron for the low-pressure end. A special provision is made to abstract progressively the water of condensation in this low-pressure end of the turbine. As will be seen from the figure, at every stage beyond the eighth a groove is provided between successive diaphragms as indicated at *d*, Fig. 5, in the case of the last stage but one. The moisture flung out by centrifugal force collects in these grooves and follows them round to the bottom of the turbine, where it drains off through orifices such as that shown at *e* in the thirteenth compartment. In the case of the later stages, these drains deliver directly to the main exhaust branch, but the drains for the eighth and ninth compartments deliver in the first instance into the box from which a steam supply is drawn for progressive feed heating. The pressure in this box, which it will be seen is connected by a suitable opening with the tenth compartment, is about 11 lb. absolute under normal full load. During the official trials the progressive feed heater was cut out of action. The drain to the first compartment shown at *f*, Fig. 5, is used merely at starting up. At the main glands special provision is made, not merely to prevent oil from the bearings entering the turbines, but also to prevent the steam from the glands getting access to the lubricating oil. To this end two packings are fitted as shown at *g* and *h*. At the low-pressure end steam leaks from the gland into the turbine and blows directly on to the hub of the last wheel. This steam is superheated, and to reduce any consequent distortion of the last wheel hub the latter is fitted with a shield of sheet metal as indicated at *i*, in Fig. 5.

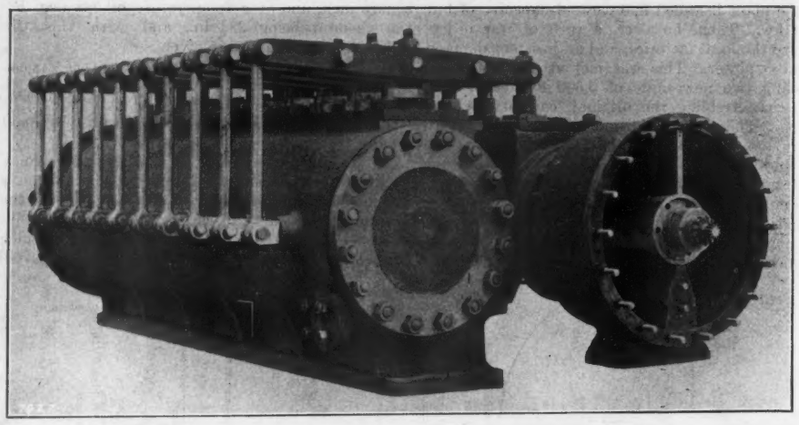


FIG. 11.

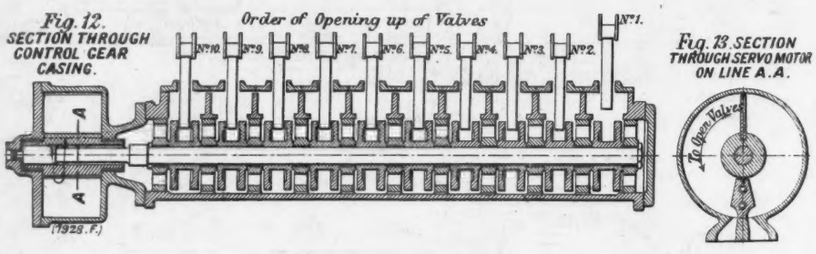
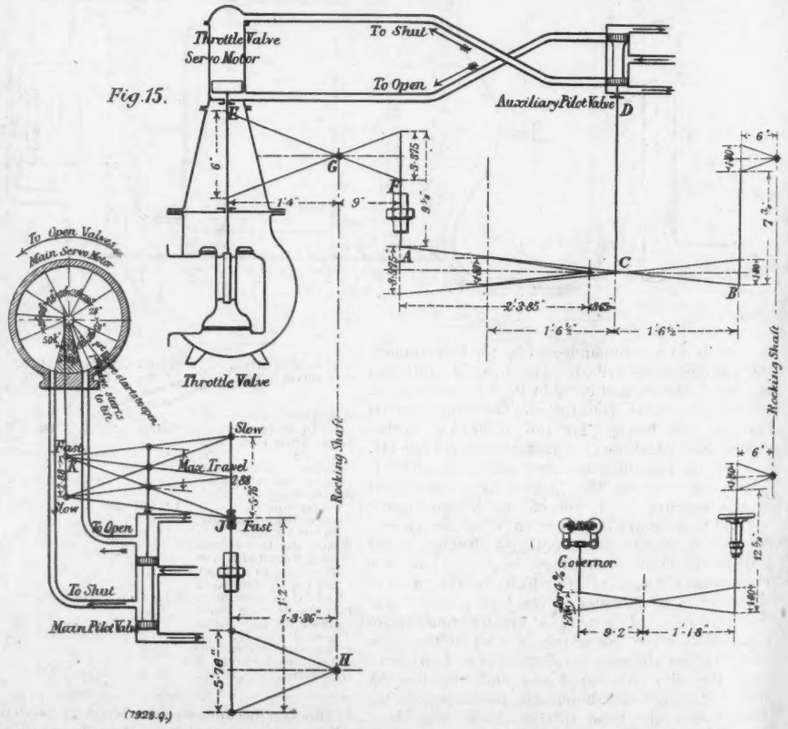


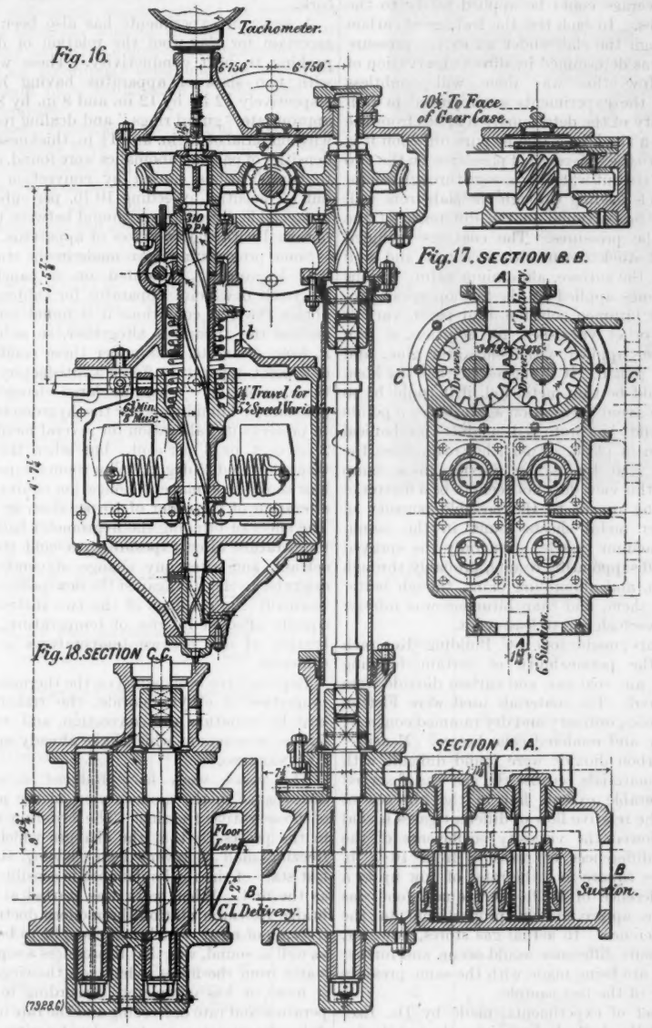
Fig. 12.
SECTION THROUGH CONTROL GEAR CASING.
Order of Opening up of Valves
N°10. N°9. N°8. N°7. N°6. N°5. N°4. N°3. N°2. N°1.
(1928.F.)
Fig. 13. SECTION THROUGH SERVO MOTOR ON LINE A.A.
To Open Valves



The thrust bearing is of the multicollar type. It is made in halves pinned together, and the complete bush thus formed is turned with a screw thread on its outer periphery, which engages with a nut as indicated. Teeth are also provided at the middle of the bush, and these gear with the worm shown at *j* below. By means of this worm the axial position of the rotor can be very quickly and conveniently adjusted. A photograph of one-half of the block is reproduced in Fig. 14, on page 66.

The emergency governor is fitted at *k*, and this will be described later on. A short shaft *l* pinned to the main shaft carries the multiply-threaded worm with which the main governor and the oil pumps are driven. At the other end a flexible coupling of the claw type unites the turbine and generator shafting.

The steam inlet for the nozzles in the lower half of the casing is represented at *m*, Fig. 5, whilst the nozzle valve-box which supplies the upper set of nozzles is indicated at *c*. Enlarged views showing details are given in Figs. 9 and 10, Plate III, whilst Fig. 11, page 66, is reproduced from a photograph of the valve box complete with its servo-motor. Sections through the latter are shown in Figs. 12 and 13. The servo-motor, which is operated with oil, is of a simple rotary type not dissimilar from some forms of blower. Oil under a pressure of about 60 lb. per square inch is admitted by valves operated by the governor to one side or the other of the vane shown in Fig. 13. This vane is mounted on a long shaft carrying 10 cam plates, each of which controls one nozzle valve. These cams are lettered *o* in Figs. 9 and 10. As the cam moves round to the right, the roller *p* engages with the forked lever *q*, and, rotating this, lifts the valve *v* by the linkage shown. During this motion the pin *r* on the left-hand side of the forked lever *q* is depressed, and as the cam-plate moves round further is caught under the lips on the plate which are best seen in the cross-section, Fig. 10. Once fully open therefore the valve is held in the same position even should the motion of the shaft be continued further in the same direction as before. Such additional motion will therefore, whilst opening additional valves, have no effect on valves already fully opened. Should the load fall off, the cam plate moves in the other direction, and the roller *p* will ultimately come into contact with the left-hand side of the forked lever *q*, and raising this will close the corresponding valve by a positive motion.



An elevation, a side view, and a plan of the steam end of the turbine are reproduced in Figs. 6, 7 and 8. The letters marking the various valves have already been referred to. The connections between the governor and the speed control valves are also shown in these figures, but will be better understood on reference to the diagrammatic sketch reproduced in Fig. 15, page 63. Here the governor is represented in the right-hand bottom corner. It is coupled by the linkage shown to the floating lever A B, to which the pilot valve for the servo-motor operating the lower half governor valve *b*, Fig. 7, is coupled by the rod C D. The rod between the piston of the servo-motor and the governor valve below it, is coupled to a lever, the outer end of which supports one end of the floating lever A B. The lever E F is keyed at its fulcrum to the rocking shaft indicated diagrammatically by the line G H, and as the piston of the servo-motor moves, this shaft is rocked to or fro. At H a lever is mounted on it, and this is coupled to one end of a second floating lever J K, from which the pilot valve supplying oil to the second servo-motor derives its motion. The ports for this second pilot valve are so arranged that no oil is supplied to the upper or main servo-motor until half-load is exceeded. It then comes into action and takes entire charge of the governing. With further increases of load, the lower governor valve is, it is true, opened still more widely, but as it is already running full bore at half-load no more steam is supplied to the lower group of nozzles.

A section through the main governor is reproduced in Fig. 16, where *l* represents the driving shaft which, as already mentioned, is pinned to the main turbine shaft. The speed can be adjusted by compressing the regulating spring by the worm wheel and screw shown. The fulcra on which the governor weights turn have ball bearings. The drive for the oil pumps is represented on the opposite side of the driving worm. These pumps are of the gear type as indicated in Fig. 18, and are shown in plan, together with the oil strainers in Fig. 17. There are four of these strainers, which consist of perforated cylinders covered with wire gauze. The springs, shown near the bottom of them in Fig. 16 are merely intended to facilitate cleaning and replacement, since when the cover is removed they raise up the strainer to a position in which it can easily be got hold of. During the operation of replacement the particular strainer involved is out of action, but the other three continue to function. This pump provides oil for the servo-motors at a pressure of 60 lb. per square inch. That required for the bearings is passed through a reducing valve. Three oil coolers are supplied, each with a cooling surface of 400 sq. ft. They are coupled in parallel and are piped so that any one can be taken out of service without interfering with the running of the unit. The cooling water supplied amounts to 40 gallons per minute. There is also a steel settling tank of 1,200-gallon capacity through which the oil is passed on its way to the coolers.

(To be continued.)

PHYSICAL ASPECTS OF FOOD PRESERVATION.

OF all means of preserving food none is so secure as those that depend on purely physical agencies and are provided by engineering methods. With increasing knowledge of these methods, increasing confidence in them, and a steadily growing population the demand for the appliances that engineers supply for preserving food must continue to increase. They will be needed not merely to provide for an increase in imported foodstuffs, but to preserve the copious excess of supply that occurs on occasions of glut for distribution over the leaner periods when the food is scarce. The extent of this increase must depend largely on the increase of knowledge as to the precise effect of the physical processes on the objects or substances preserved; the time for which the preservation will last, the changes that it induces in the texture and palatability of the preserved food, the difficulties that are met in applying the preservative processes, and the means available for overcoming them.

Such questions are of grave importance to the community, and have a corresponding interest to the engineering industry, whose products are involved in their solution. With the mass of scientific and technical material that engineers have to consider, many competent men are disposed to regard such questions as lying outside the sphere of their proper interests. With every sympathy for men already overburdened with the need for knowledge it is impossible to admit this as a prudent view. Not only the extent to which engineering manufactures will be required for preserving foods, but the manner in which they should be designed and will work, must depend essentially on the precise effect they produce on the objects on which they are used, and a far-seeing manufacturer should be among the first to have the advantage of new and authentic additions to knowledge of the subject. An important document has just been issued by the Research Department's Food Investigation Board,* which

* Report of the Food Investigation Board for the year 1922. H.M. Stationery Office, 1*s.* 6*d.* net.

summarises what the Board has been doing in 1922 and has now in progress. It is perhaps a little late in appearance, and its lateness may be a reminder that work of the kind it describes is being conducted at present with an uneconomically small staff, the meagreness of which may be impeding the work in more ways than the delay in publishing reports. Nevertheless, even at this date the report is of immediate interest, and illustrates aptly the close connection between its subject-matter and that of engineering physics.

The outstanding event of the year under notice has been the equipment of the Board's low-temperature research station at Cambridge up to starting point in June, 1922. At this date the research staff were able to deal with the storage of fruit and vegetables, using to some extent makeshift appliances, and in October freezing tanks were completed and at work on supplies of fish. The equipment is even now by no means completed, many details of it having required prolonged physical experiments. In the Board's view, the correctness of which is more certain than generally recognised, the standard of accuracy of experiments on which commercial practice is to be based must be the very highest that is attainable. Often this standard is confused with that which should be adopted in commercial practice itself, in which a common and irritating mistake is to express results to an ostensible degree of accuracy in excess of what the materials or processes can yield. This mistake is doubtless to be condemned severely wherever it is met. It is the child of ignorance and pretension, and the parent of false confidence and inaccuracy. Experimental work, on the other hand, is on a different footing. Usually it is concerned not with an entire process, but with individual factors; and even when the entire process is measured under experimental conditions, it is only a part of the process as it has to be conducted in actual practice. The value of exact experimental measurements of what can be measured accurately is therefore that it not only yields a standard of attainment—which is worth having, even if it is asymptotic—but also that it subdivides the field of experiment, and thus limits the factors of practice in which errors have to be sought and eliminated.

In cold storage the principal factors to be controlled are temperature, humidity, and composition and movement of air. Up to now the station has made most progress in the control of temperature, and four chambers—size not stated—have been fitted with automatically controlled electric heating adjusted so sensitively that temperatures are maintained over long periods within 0·05 deg. C., an accuracy that hitherto has been difficult enough to obtain even with small incubators. The installation of less elaborate systems of heating in other chambers has yet to be undertaken. Some difficulty has been found in cooling the atmosphere of "gas" storage chambers, the temperature of which, although controlled readily enough in winter, is apt to rise unduly in autumn through heat generated by the fruit in store, this rise, added to the relatively high external temperature, causing an unwelcome acceleration of the ripening process. The difficulty is the greater because it occurs only during a few weeks in the year, and a small grower cannot afford elaborate machinery for such a purpose. The matter is still under investigation, but some curious results were obtained in experiments comparing the cooling effect of plain tubes with that of tubes dented in planes alternately at right angles to each other, which set up turbulence in air flowing through them, and cause both good mixture and contact with a large surface. With air flowing at the same speed the cooling power of the indented pipe was 1·66 times that of the plain pipe in still air, and double that of the plain pipe in a strong breeze. When, however, the speed of the fan was increased above a certain limit the greater resistance of the dented tube set up fan slip, and the cooling effect became less than that of the plain tube.

For the method of "gas" storage of fruit it is necessary to control the percentage of carbon dioxide in the atmosphere, and an unexpectedly high rate of diffusion of this gas through walls presented some difficulty, seeing that the method depends on accumulating up to a certain percentage the carbon dioxide exhaled by the fruit. The difficulty has not yet been completely overcome, and experiments are still in progress, but results of some general interest have been obtained incidentally. In the first instance, the desired impermeability was sought by means of wall coverings laid on slabs of plaster. In the course of these it appeared that plasters may vary in porosity, as much as 500 to 1, and "wide variations" of porosity were observed even in slabs that "had been prepared in a similar manner." These statements might perhaps have been made a little more significant without notably extending the report if they had been more specific in details. In any test the variation in porosity between individual slabs was so great that it was necessary to test each before and after coating, and no general average could be applied safely to the untreated slabs. In each test the leakage of carbon dioxide through the slab under an excess pressure on one side was determined by direct observation of pressures. How this was done will doubtless appear when the experiments are reported in full. The complexity of the determination arises from the fact that when the flow is due to pure diffusion it is proportional to the difference of pressures on the two sides of the slab, but when to passage through microscopic channels leading through the slab from wall to wall it is proportional to the difference of the squares of the pressures. The coatings included thin lead foil stuck down with seccotine and well rubbed on to the surface, aluminium paint, various metallic coatings applied by the Schoop spray process, sprayed bitumen solution, lead paint, various leather and other varnishes, tar solution, a proprietary paper applied with cold-water glue, and rubber latex paper. It is suggested that the ideal covering would be thin metal foil, if it could be so applied as to avoid perforation against sharp points of plaster and be protected against mechanical damage when in place. Apart, however, from the corrosion of lead by carbon dioxide in a damp atmosphere, this view does not seem to be a matter of course, having regard to the possible porosity of much thicker metal sheets found in the manufacture of vacuum vessels. Generally the sprayed metals gave disappointing results, probably through minute holes, and aluminium paint, though better than any of them, and than bitumen, was inferior to a special varnish and to lead paint.

Experiments made for the Building Reserach Board on the permeability of certain building materials by air, coal gas, and carbon dioxide were also considered. The materials used were Fletton and stock bricks, ordinary and dry rammed concrete, and ordinary and rendered coke breeze. Measurements of carbon dioxide were found difficult with coke breeze materials because the gas was absorbed to a considerable extent, but in the absence of absorption the relative flow of different gases is said to have followed the viscosity coefficients of the gases. On differences of pressure from 16·7 lb. to 100 lb. per square foot the rates of flow up to a pressure difference of 80 lb. per square foot was found to be approximately proportional to the pressure difference. In actual gas stores, however, no such pressure difference would occur, and further experiments are being made with the same pressure on each side of the test sample.

Another set of experiments, made by Dr. Ezer Griffiths and Mr. J. H. Awbery, investigated the lag in thermometer readings that occurs when a thermometer used, say, in a ship's hold, is withdrawn and carried for reading into another part of the vessel, and the influence of any rapid change of temperature that happens to be going on at the time in the chamber under examination. The results of this investigation, including tables recording the magnitude of the errors shown on individual thermometers and formulæ applicable to any thermometer, are given in a paper published in the Transactions of the Faraday Society for 1922.

Several sets of investigations were made into heat-insulating materials, such as are used in cold storage. In one, tests were carried out over a period of 700 hours to determine the absorption of water by expanded rubber, as well as shorter tests on other materials, control tests being made on a sheet of solid red rubber. The measurement was of different weights before and after submersion in water, surfaces being dried after removal from the water with blotting paper and absorbent cotton wool. Even the solid rubber had a capacity, said to be by no means negligible, for holding water, which is in accordance with its known microscopic structure of a close-textured sponge of elastic fibrils. Balsa wood absorbed nearly 250 per cent. of its weight in eight days, expanded rubber about 14 per cent. in eight days, and cork slab 32 per cent. in five days. The factors by which the rates of absorption are affected are at present not explained.

Insulation tests under the ordinary conditions of cold storage are at present in progress at Smithfield for comparison with those made at the National Physical Laboratory, and include tests on compressed peat, Balsa wood, charcoal, slag wool, Saragosa grass, and granulated and compressed cork.

A series of experiments has also been made to ascertain for slag wool the relation of density of packing to heat conductivity. These were made with two sizes of apparatus having hot plates respectively 12 in. by 12 in. and 8 in. by 8 in., with appropriate "guard rings," and dealing respectively with material of $1\frac{1}{2}$ in. and $1\frac{1}{8}$ in. thickness. At low densities of packing anomalies were found, attributed to complications caused by convection currents; but at densities exceeding 10 lb. per cubic foot no appreciable difference was found between the results obtained with the two sizes of apparatus.

Some progress has been made in the study of the hair hygrometer, mounted on a panel with a Regnault dew-point apparatus for calibration. To obtain the best conditions it is found necessary to enclose the apparatus altogether, so as to protect it from draughts, and under these conditions the dew-point apparatus affords a satisfactory check on the hygrometer. Where no large changes of temperature or humidity occur the hygrometer appears to preserve its calibration for several months within 2 per cent. or 3 per cent., but when the temperature is lowered 25 deg. C. below room temperature the hair shows a permanent elongation equivalent to an alteration of the order of 10 per cent. in humidity. The effect of bringing the hygrometer back to room temperature after exposure in a cold store is uncertain, and after any change of conditions it is desirable to check it against the dew-point apparatus. Normally the readings of the two instruments are equally affected by rise of temperature, and calibration at one or two temperatures is therefore sufficient.

Reports have been issued on the thermal and other properties of ethyl chloride, the transmission of heat by radiation and convection, and refrigerator barges, accounts of which have already appeared in ENGINEERING.

The year's work has produced a remarkable disturbance in the modern view of the mechanism of preservative freezing. The criterion of success in the process is that the changes which occur in freezing shall be reversed on thawing, so that the last state of the food substance is sensibly the same as the first. When work was started at the Cambridge Research Station the modern doctrine of the freezing of meat, which was thought to be complete as well as sound, was that it produces a separation of water from the fibres, which, on thawing, reabsorb it more or less completely, according to the temperature and rate of freezing and the rate of thawing. A low freezing temperature, slow freezing, and rapid thawing each tend to prevent reabsorption of the water, while very rapid freezing even to the lowest temperatures practically prevents the separation of water from the fibres and chemical alterations in the meat disclosed on thawing after slow freezing. While, however, methods were being elaborated for determining the critical rate of freezing that has to be obtained in order to preserve meat without modifying its chemical structure, the station was asked to investigate the freezing of eggs on behalf of the Engineering Committee. It was found that at whatever rate eggs are frozen or thawed, they thaw out to the same apparent state as unfrozen eggs if the temperature is not allowed to fall below — 5 deg. C.; but that if frozen at a lower temperature, or exposed to it in storage after freezing, both the whites and the yolks are completely changed, the extent of the change varying with the lowness of the temperature. This discovery shows that the previous theory is at least incomplete, and at present the problem that is to be put to refrigerating

engineers remains in suspense. The report notes incidentally that the expansion of the water of the egg cracks the shell on freezing unless at least 4 per cent. of the water is dried off before freezing. It does not mention whether enough water to bring their water percentage to about the same as that of meat can be removed from eggs by drying without altering their chemical structure in other respects. In any case freezing experiments do not seem to have been made on eggs in that condition, nor are any observations mentioned indicating how far the effect of freezing on animal tissues depends on the percentage of water and the manner in which it is distributed in the tissues.

Among other results obtained by the Fish Preservation Committee, it was found impossible to devise a sufficiently simple method of preserving fish for a fortnight without the use of cold or of hygienically excessive amounts of antiseptics, and attempts are accordingly being made to obtain the desired result by a combination of antiseptics and low temperature.

Important chemical, mycological and other biological results have been obtained by the Meat, Fruit and Vegetables, and Oils and Fats Committees through work done for them at various institutions and in stores, and some practical information resulted from cold and gas storage trials.

THE STRENGTH PROPERTIES OF WROUGHT IRON, MILD STEEL AND NICKEL STEEL AT HIGH TEMPERATURES.

By H. CARRINGTON, B.Sc.Vict.; M.Sc.Tech.; A.M.I.Mech.E.

Introduction.—Of the many researches which have been carried out on the behaviour of iron and steel under test at various temperatures, the most complete are probably those of Professor A. Martens,* who examined the strength properties and Young's Modulus for three grades of steel between 60 and 1,000 deg. F. Professor Martens' results show, in particular, that in the region between 200 deg. and 500 deg. F. there is a marked increase in the ultimate strength and decrease in the elongation, the curves passing through maximum and minimum values respectively in this region. His curves indicate a steady fall in the ultimate strength as the temperature rises beyond about 450 deg. F., the value at 800 deg. F. being a little more than one-half that at 60 deg. F. The results indicate that whereas a steel may be up to specification at normal temperatures it will probably fall below it as regards either ultimate strength or elongation, or both, at temperatures even as low as about 150 deg. F., for the elongation beyond 60 deg. F. falls rapidly, and in the region of the boiling point of water is only about one-half its value at 60 deg. F.

The more important features of Professor Martens' results have been confirmed by subsequent researches, the most recent being those of Professor C. F. Lea.* The research described in this paper was conducted upon modern wrought iron, mild steel and nickel steel, and is to some extent a repetition of Martens' work. The research includes, in addition, the relations between the Sankey Test properties, Poisson's Ratio and the temperature for the three materials, relations which do not yet appear to have been published.

The Specimens and Method of Testing.—The material was ordinary $\frac{7}{8}$ in. dia. bar wrought iron, mild steel and nickel steel. The mild steel contained 0·19 per cent. of carbon, and the analysis of the nickel steel was:—

	Per Cent.
Carbon	0·19
Manganese	0·55
Phosphorus	0·027
Sulphur	0·029
Silicon	0·098
Nickel	3·41

The bars were all annealed at about 1,670 deg. F. for half an hour before preparation and allowed to cool off in the furnace.

The tensile test specimens were $\frac{1}{2}$ in. diameter for an effective length of 4 in. Heating was obtained by passing a current through them from a small transformer, which is shown connected to a specimen

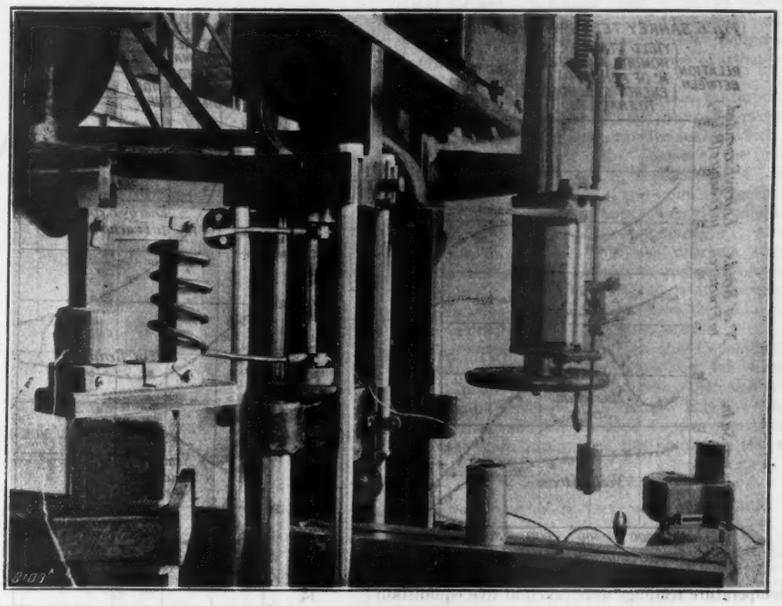


FIG. 1.

Fig. 2.

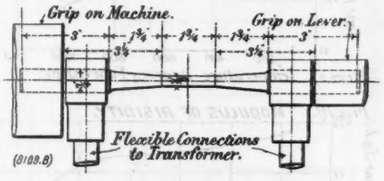


Fig. 3. TENSILE TESTS. WROUGHT IRON.

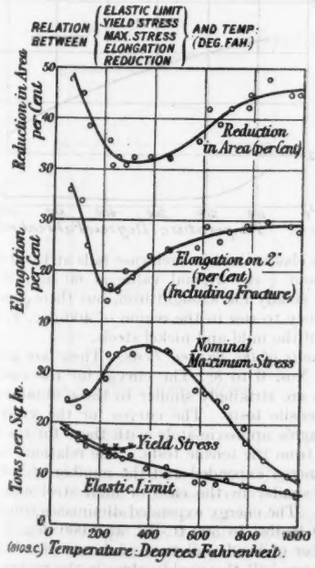


Fig. 4. TENSILE TESTS. MILD STEEL.

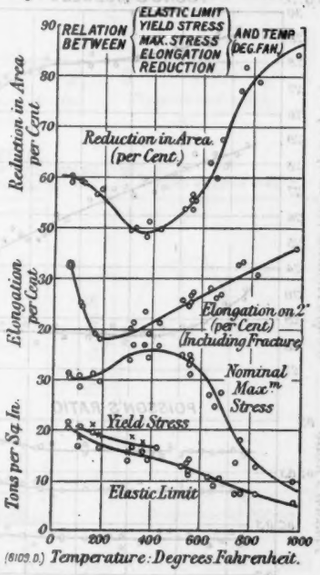
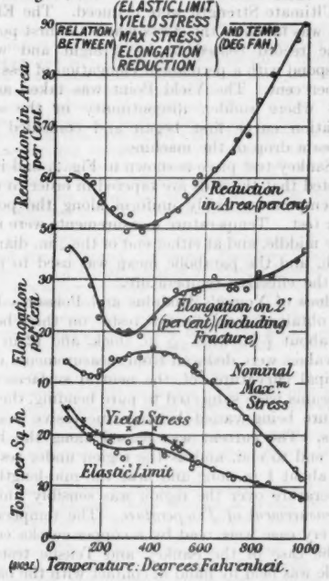


Fig. 5. TENSILE TESTS. NICKEL STEEL.



* Min. Proc. Inst.C.E., vol. civ, 1891.

* ENGINEERING, August 27, 1920, and Proc. Inst. Mech.E., June, 1922.

in Fig. 1. This method of heating caused the mid-length of the specimens to be always hotter than the ends, and it was therefore decided to make the enlarged ends as long as the machine would permit in order to cause the temperature over the effective tested length to be as uniform as possible (Fig. I). The variation in temperature along the effective portion is also indicated in this figure, the blue colour near the ends showing darker than the lighter colour corresponding with the hotter region in the middle. Because of the variation in the temperature readings were taken at five equidistant points, so that by noting the position of the fracture the actual temperature there could be determined.

Autographic records were obtained for each test piece, and from these the Elastic Limit, Yield Stress, and Ultimate Strength were deduced. The Elastic Limit was taken as the stress where the first portion of the record ceased to be straight and would correspond with a permanent elongation of less than 0·5 per cent. The Yield Point was taken as the stress where sudden discontinuity in the stress elongation curve first began and coincided with the beam drop of the machine.

A Sankey test piece is shown in Fig. 2, and it will be noted that the ends are tapered in order to make the temperature fairly uniform along the portion under test. Temperature measurements were noted at the middle, and at either end of the $\frac{3}{8}$ in. diameter length, and the parabolic mean was used to represent the effective temperature.

Values of Young's Modulus and Poisson's Ratio were obtained from flexure tests* on three beams, each about $\frac{3}{4}$ in. wide, $\frac{1}{16}$ in. thick, and 12 in long. The values were deduced from measurements of the principal curvatures of the neutral surfaces when the beams were subjected to pure bending, the temperature being varied between successive measurements. The current was passed along the beams from end to end, and as the region under test was only about 1 in. long and near the mid-length, the temperature over the region was sensibly uniform.

Measurement of Temperature.—The temperatures in every case were read by a copper-eureka couple. In the case of the Sankey and Tensile tests the couple was held by hand in contact with the bars by a glass rod, for it was found that better contact could thus be obtained than by clamping it to the specimens. A clamp had, however, to be used for the bending of specimens. A couple was fixed in position at the commencement of each of the three series of bending experiments and remained there until its completion.

Results of the Tensile Tests.—These are illustrated in Figs. Nos. 3 to 5, and it will be noted that the general shapes of the curves for the three materials are very similar. The elongation in each case falls to a minimum between 200 deg. and 300 F. deg. of approximately one-half its value at 60 deg. F. It then rises up to 1,000 deg. F., but does not reach its original value at 60 deg. F. in the case of wrought iron. It passes through it in the case of mild steel and nickel steel at about 800 deg. F. and 1,000 deg. F. respectively.

The curves for the reduction are approximately similar to those for the elongation. They pass through minima between 300 deg. and 400 deg. F., the reduction in this region being about $\frac{3}{4}$ that at 60 deg. F. for wrought iron and about $\frac{5}{6}$ for mild steel and nickel steel. In the case of wrought iron the reduction does not quite reach its original cold value at 1,000 deg. F., but passes through it in the case of mild and nickel steel at about 600 deg. F., and then rises 50 per cent. above it at 1,000 deg. F. The ultimate strength shows a tendency to fall up to 200 deg. F., and then rises to a maximum at about 400 deg. F. Beyond this temperature it diminishes steadily to about 10 tons per sq. in. at 1,000 deg. F., passing through its original value at 60 deg. F. at about 650 deg., 600 deg., and 550 deg. F. for wrought iron, mild steel, and nickel steel respectively.

In the case of wrought iron the yield stress falls to a minimum of about $\frac{3}{4}$ its original cold value at 300 deg. F. It then rises slightly, but this is not evidenced beyond 400 deg. F. The mild steel showed no yield when cold and beyond 400 deg. F. The yield point for the nickel steel was evidenced up to 600 deg. F., falling to about $\frac{5}{6}$ its original value at between 200 deg. and 400 deg. F., and then falling again up to 600 deg. F.

The elastic limit in each case falls at 1,000 deg. F. to about $\frac{1}{3}$ its original value at 60 deg. F. The fall is steady for wrought iron, but there is a slight tendency to rise in the region of 400 deg. F. in the case of the mild and nickel steels.

Results of the Sankey Tests.—These are given on Figs. Nos. 6 to 8. The curves for the maximum stress are strikingly similar to those obtained from the tensile tests. The curves for the yield stress also agree approximately with those for the elastic limit from the tensile tests. The relations between the energy expended and the number of bends are very similar in the case of mild steel and nickel steel. The energy expended diminishes from about 5,000 ft.-lbs. to 500 ft.-lbs. at 1,000 deg. F. The number of bends fall to a minimum of a little less than one-half their cold values in the region of 500 deg. F. for mild steel and 700 deg. F. for nickel steel. They then rise slightly to about one-half their cold values at 1,000 deg. F. There is a slight tendency to rise in both the energy and bend curves for nickel steel in the region of 300 deg. to 400 deg. F., which is absent from the curves for mild steel.

The curve for the energy expended for wrought

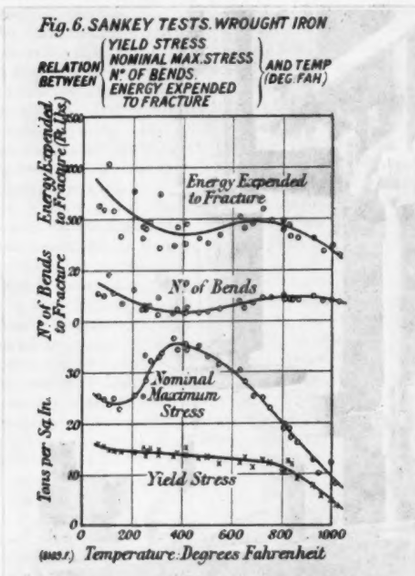


Fig. 6. SANKEY TESTS. WROUGHT IRON
RELATION BETWEEN (YIELD STRESS, NOMINAL MAX. STRESS, N° OF BENDS, ENERGY EXPENDED TO FRACTURE) AND TEMP (DEG. FAH)
Energy Expended to Fracture (Ft. Lbs)
Energy Expended to Fracture
N° of Bends to Fracture
N° of Bends
Tons per Sq. In.
Nominal Maximum Stress
Yield Stress
Temperature: Degrees Fahrenheit

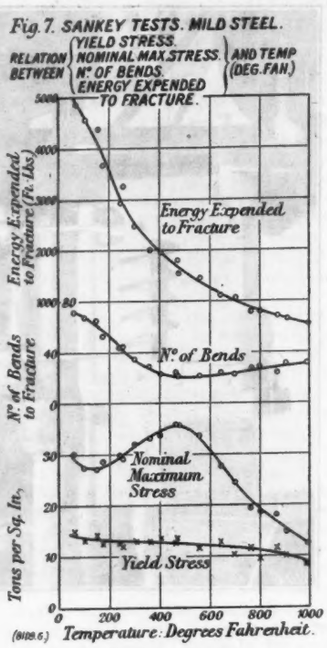


Fig. 7. SANKEY TESTS. MILD STEEL.
RELATION BETWEEN (YIELD STRESS, NOMINAL MAX. STRESS, N° OF BENDS, ENERGY EXPENDED TO FRACTURE) AND TEMP (DEG. FAH.)
Energy Expended to Fracture (Ft. Lbs.)
Energy Expended to Fracture
N° of Bends to Fracture
N° of Bends
Tons per Sq. In.
Nominal Maximum Stress
Yield Stress
Temperature: Degrees Fahrenheit.

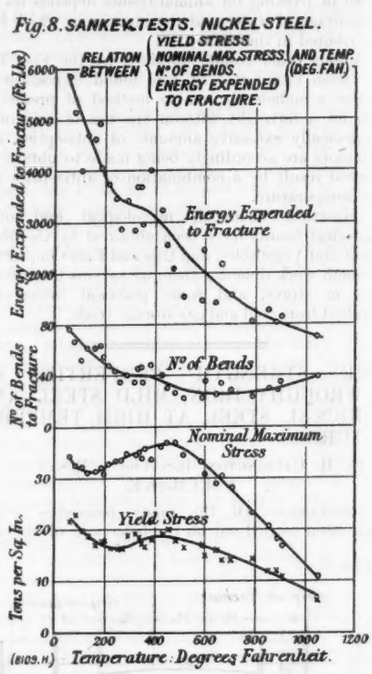
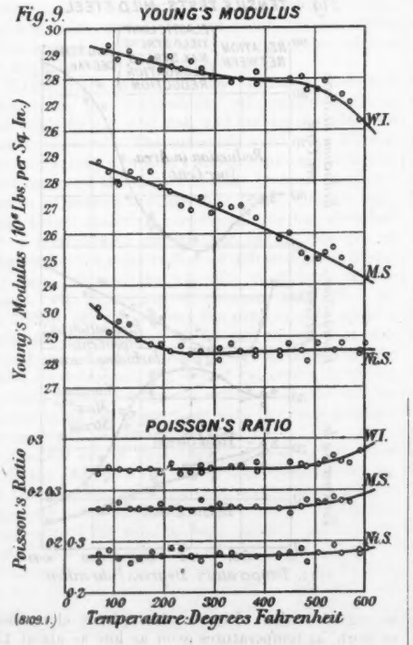
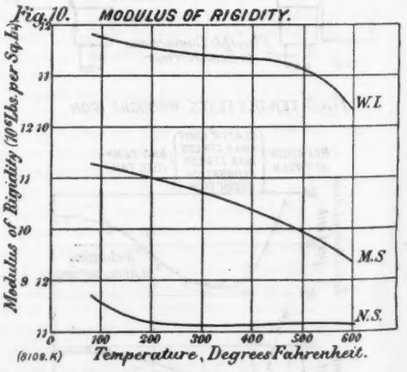


Fig. 8. SANKEY TESTS. NICKEL STEEL.
RELATION BETWEEN (YIELD STRESS, NOMINAL MAX. STRESS, N° OF BENDS, ENERGY EXPENDED TO FRACTURE) AND TEMP. (DEG. FAH.)
Energy Expended to Fracture (Ft. Lbs.)
Energy Expended to Fracture
N° of Bends to Fracture
N° of Bends
Tons per Sq. In.
Nominal Maximum Stress
Yield Stress
Temperature: Degrees Fahrenheit.





* *Phil. Mag.*, February, 1921.

iron is similar to that for the number of bends. They both reach minima at about 400 deg. F. of slightly less than one-half the values at 600 deg. F. The energy expended rises slightly to about 700 deg. F., and then diminishes again at 1,000 deg. F. to about one-quarter its cold value. The number of bends rises beyond 400 deg. F., and at 1,000 deg. F. is a little more than one-half its value at 60 deg. F. It will be noted that at 60 deg. F. the energy expended and number of bends for wrought iron are 8 per cent. for mild steel and 4 per cent. for nickel steel.

The relations between the moduli of rigidity and the temperature are shown on Fig. 10. These curves were constructed from the values of Young's Modulus and Poisson's Ratio, assuming the materials to be isotropic. It will be noted that for each material the modulus of rigidity varies with the temperature in a manner very similar to Young's Modulus.

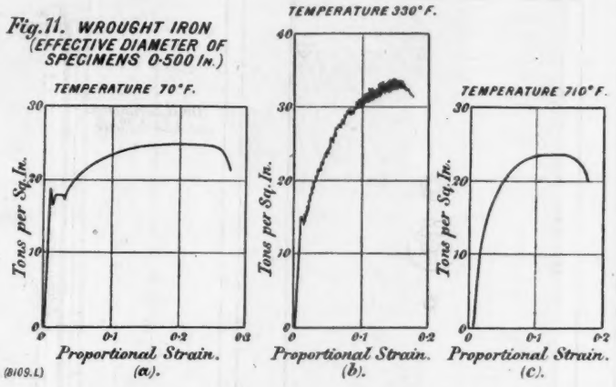


Fig. 11. WROUGHT IRON (EFFECTIVE DIAMETER OF SPECIMENS 0·500 IN.)

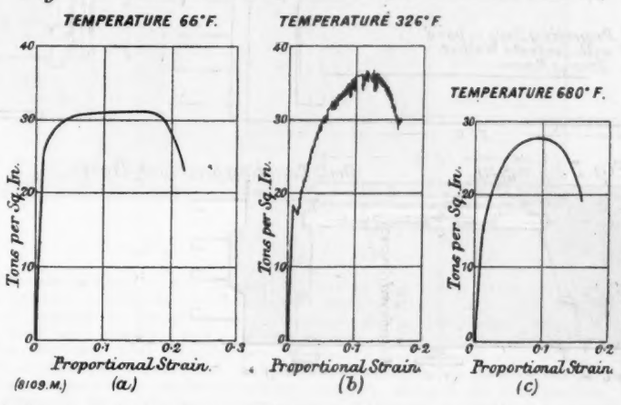


Fig. 12. MILD STEEL. (EFFECTIVE DIAMETER OF SPECIMENS 0·500 IN.)

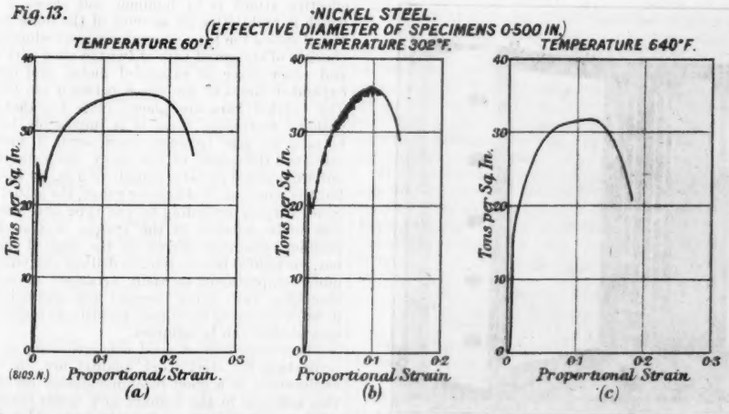


Fig. 13. NICKEL STEEL. (EFFECTIVE DIAMETER OF SPECIMENS 0·500 IN.)

only about one-fifth those for mild steel and nickel steel.

Results of Flexure Experiments.—These are shown in Fig. 9. Young's Modulus in every case decreases with increase of temperature up to 600 deg. F. In the case of wrought iron its value at 400 deg. F. is 4 per cent. less than at 60 deg. F., and is about 10 per cent. less at 600 deg. F. In the case of mild steel the modulus falls steadily, its value at 600 deg. being about 15 per cent. less than that at 60 deg. F. The modulus for nickel steel falls by about 5 per cent. at 300 deg. F. and then remains nearly constant up to 600 deg. F. Poisson's Ratio remains constant up to about 450 deg. F., and then rises at 600 deg. F. by about 16 per cent. for wrought iron, 400 deg. F. They then diminished in intensity and disappeared altogether at 500 to 600 deg. F., the records beyond this temperature being as shown at *c*. It seemed that beyond 175 deg. F. the yield gradually extended itself over the plastic region of the curve, for as the irregularities became more pronounced the extension at the yield became less. The irregularities were accompanied by slight sounds issuing from the bars as if the crystals were slipping along each other. The sounds were heard when a downward stroke of an irregularity was formed. A similar state of affairs was noted in the case of the Sankey tests, for a slight jerkiness was felt when bending specimens at temperatures corresponding with the appearance of irregularities in the tensile records.

The Autographic Records.—Three typical records for each of the three materials are shown in Figs. 11, 12 and 13. The yield for the wrought iron and nickel steel is pronounced at 60 deg. F., but in the case of the mild steel was not evidenced below 120 deg. F. As the temperature increased the yields became less pronounced and finally disappeared altogether at about 400 deg. F. for wrought iron and mild steel, and at 600 deg. F. for nickel steel.

The records marked *b* in the figures illustrate an interesting feature. As the temperature increased through about 175 deg. F., incipient irregularities appeared in the region between the yield and the maximum load, which became more pronounced as the temperature passed through 300 deg. to

Conclusion.—The results emphasise the importance of knowledge concerning the strength properties of the materials at temperatures under which they are to be employed. For instance, the critical region between 200 deg. F. and 300 deg. F., where the elongation reaches a minimum, suggests that impact or endurance tests in this region would give results much inferior to those at 60 deg. F. Another instance is the fact that the ultimate strength diminishes rapidly as the temperature increases through the region of 700 deg. F., which is evidently of great significance in cases where the metal comes into contact with superheated steam.

The author is indebted to the Department of Scientific and Industrial Research for a grant, which made his research possible. He also wishes to thank Professor G. Stoney, F.R.S., through whom the grant was obtained, for many suggestions and the keen interest he has shown in the work throughout.

STANDARDISATION IN CANADA.—The formation of a committee to draft standard specifications for steel structures for buildings was approved at the tenth meeting of the Main Committee of the Canadian Engineering Standards Association, held at Ottawa, says *The Canadian Engineer*. This work is to be carried on in co-operation with a similar committee in the United States. In the preliminary stages of the work, assistance will be given by the Engineering Institute of Canada, leading firms engaged in the manufacture of steel structures and well-known engineers also engaged in this branch of work.

FRICTION TRANSMISSION.—The firm of Ferodo, Limited, of Sovereign Mills, Chapel-en-le-Frith, who have done so much in the development of friction fabrics for brake and clutch linings, have now placed upon the market a moulded composition for lining the wheels of friction transmission systems. With a view to showing its utility on application to the many types of friction drive, the firm have issued a booklet relating to the power-transmitting capacity of the substance, the permissible pressures on the contact faces and the efficiency of transmission. This compilation of data will prove of service to all users of friction drives, and a copy may be had on application to the manufacturers.

PRICES OF IRON AND STEEL.—Messrs. W. Richards and Sons, Limited, Britannia Foundry, Middlesbrough, have issued a chart printed in colours showing the prices of iron and steel from 1914 to date, with room to extend the record up till the end of 1924. The diagrams give stepped curves for pig-iron, rails, steel plates, bar iron, iron castings, iron rivets and steel angles and joists. A curve showing the Bank rate is also included. The curves are all made distinct either by colour or dotting, etc. The war period is tinted red and the period of the coal strike of 1921 is noted. The high post-war prices are very noticeable when plotted in this way, though some distortion is given to the curves due to the fact that the earlier years are not allotted the same space on the horizontal scale as those of more recent date.

THE GERMAN RAILWAYS.—According to *The Railway Review*, Chicago, Hugo Stinnes is trying to force the Government to sell him the 30,000 miles of German nationally owned railways; the League of German Industries in executive session recently considered the project. The chief associates of Stinnes are Peter Kloeckner, coal magnate, and Albert Voegeler, iron king of Silverberg, head of the coal syndicate. Government experts estimate the value of the railways at $7,500,000,000. Stinnes, it is said, estimates them at much less. The Government railways are facing financial breakdown. They must pay 190,000 officials and employees on lines in the Ruhr and Rhineland, from which there is no revenue because they are in the possession of the French. Stinnes and his associates are charged with attempting to influence the Rentenbank to refuse any capital to operate the Reich railways. With the railways under his control, Stinnes would be the undisputed master of Germany. Stresemann, the Foreign Minister, has stated, our contemporary adds, that "Stinnes will not get the railways so long as I am in the Government." One inference to be drawn from the above information is that Germany as represented by her industrialists, is not so poor as is generally made out.

THE FORTIS REINFORCED CONCRETE SAFES AND STRONG ROOM DOORS.

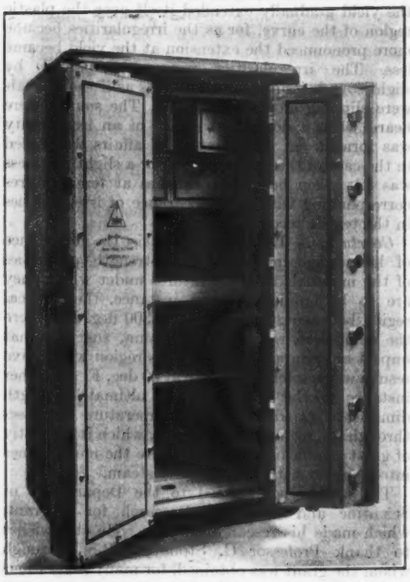


FIG. 1.

Fig. 2.

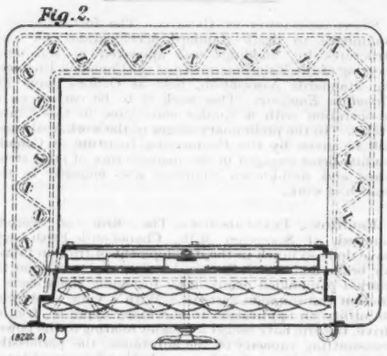


Fig. 3. FRONT ELEVATION.

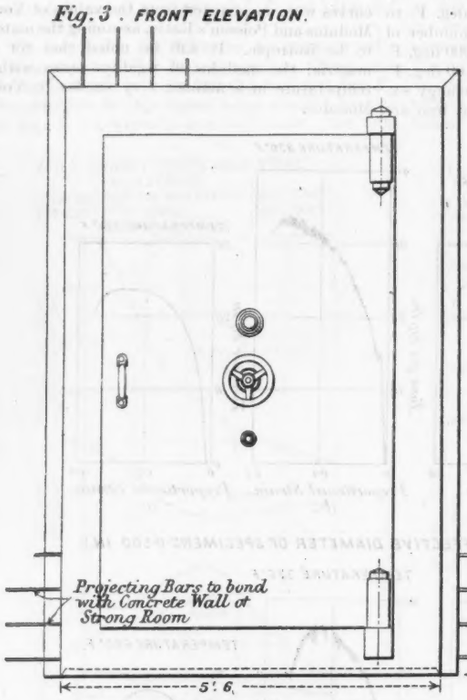


Fig. 4. SECTIONAL ELEVATION

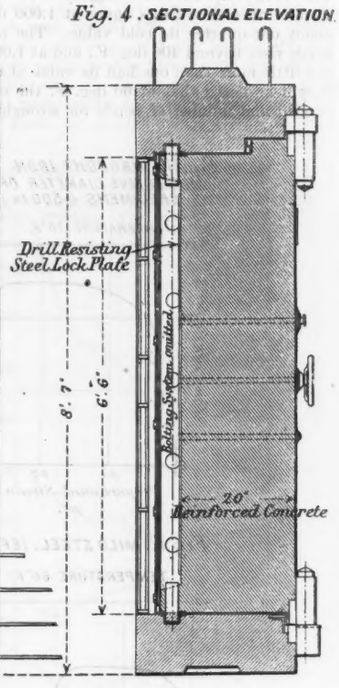


Fig. 5.

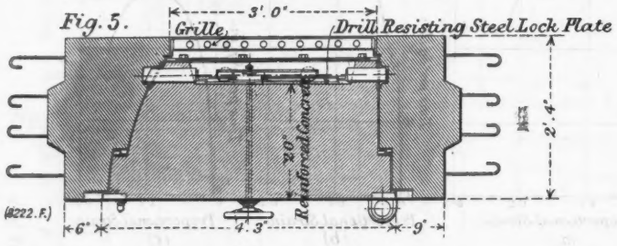


FIG. 6.

ENGINEERS are familiar in a general way with the wide range of work for which it is customary now-a-days to employ reinforced concrete. This material is now generally accepted as giving satisfactory results from the point of view of durability and strength, and of possessing high fire-resisting qualities. One of the latest developments of the use of reinforced concrete is in connection with bank strong rooms, which, however, in principle, involves no great departure from usual constructional practice with this material, though the application and degree of protection afforded varies with the manner in which it is utilised in particular cases. An altogether unique departure on the other hand, is to be found in the use of reinforced concrete for strong-room doors and also for complete safes of both large and small sizes.

The ordinary safe consists usually of an outer and inner casing of steel sheet with a filling between them of some fireproof material. Such safes afford a certain amount of protection, but are not proof against the oxy-acetylene blow-pipe, which can cut through great thicknesses of steel with ease. Further protection by multiplying the thicknesses and quality of the steel plate afford little safeguard against this mode of attack. Even if concrete be used as a filler, any metal connection extending from the outer skin to the interior at once provides a vulnerable point. Again, in the matter of fire, the steel plating connected with the interior is liable to become so heated as to damage the contents, while in the case of a fall from any height on to hard ground, the heated steel casing only too often becomes distorted so that protection is nullified.

With a view to finding a material with greater power of resistance in these directions, re-inforced concrete has now been applied and successfully adopted for safes which are accepted by insurance companies as satisfactory. In Figs. 1 and 2 on this page, we give illustrations relating to safes of this kind of the Fortis Reinforced Concrete Safe Company, Limited, of Thanet House, 231, Strand, London. In these, reinforced concrete is used for the whole body of the safe, as well as the doors.

The illustration, Fig. 1, is a view of a safe with double doors, and is of one of the larger sizes, but single-door safes of various sizes are being made down to interior measurements of 19½ in. by 14 in. by 12 in., so that the construction is adaptable to requirements of all kinds. The construction reduces to a minimum the use of exposed metal, and for all practical purposes is immune from damage by oxy-acetylene flame. It cannot be drilled on account of the combination of concrete and reinforcement and the only means of effective attack is by hammer and chisel, a method which is prohibitive on account of the noise produced. Fig. 2 shows the type of reinforcement adopted. This consists of staggered bars of twisted steel with an inner and outer layer of expanded metal, and corrugated expanded metal in the space between the two latter. The twisted bars are placed close together so that without destroying them it is impossible for a man to pass an arm between them, even if success has attended the effort to cut away the concrete. The outer expanded metal is usually of 3-in. by 1½-in. mesh, but the inner one is of heavier gauge, the actual arrangement varying according to the type and size of safe. The main reliance in the system is placed on the peculiar resistance offered by the edge of the twisted bar, embedded in concrete, to drilling and cutting. An inner compartment is easily arranged in such safes, sheet-iron walls being inserted and grouted in, while in safes requiring maximum security an inside lining of special steel can be adopted.

The recognition of good concrete work as effective protection for steel work against fire, in structural engineering, is a good recommendation for the use of this material in the manner now under consideration, while its low heat conductivity provides a greater safeguard against damage by scorching than does metal plating. The importance of preventing the penetration of flame or hot gases round the edge of the door has been fully realised, and from Fig. 2 it will be seen that effective steps have been taken to make such access to the interior as difficult as possible. Around the edges of the door is a rim of steel, fitting into a ring set in the body, while midway between the in and the out side is a double rebate of sectional steel, a rebate forming part of the door mating with one set in the body, providing an efficient firelock embedded deeply in the concrete and protected by a considerable thickness. The door opening is of concrete in which on all four sides steel lined sockets are placed into which the bolts securing the door are shot. There is no through metallic connection from the interior to

THE FORTIS REINFORCED CONCRETE STRONG ROOM DOORS.

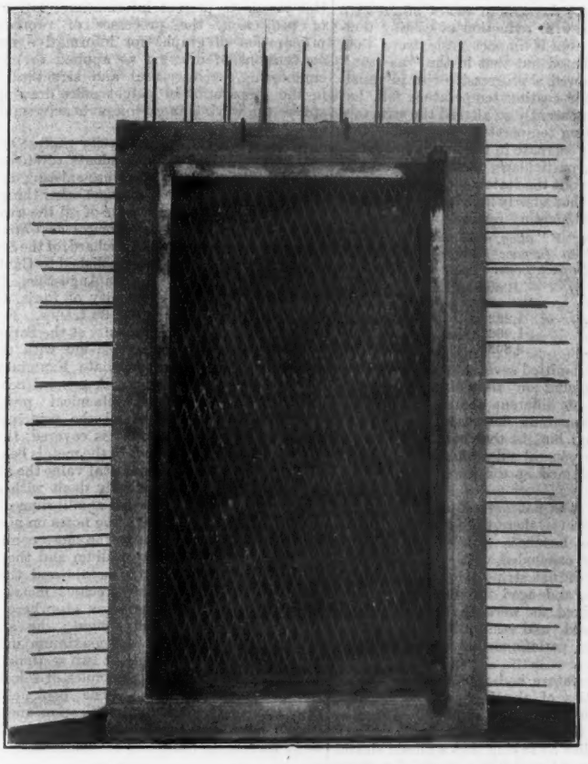


FIG. 7.

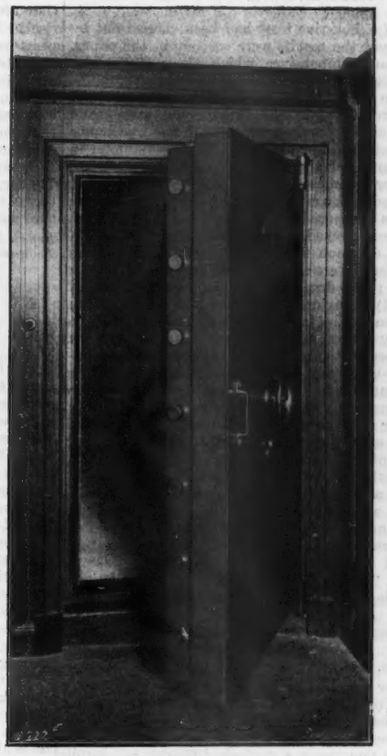


FIG. 8.

the outside. The solidity of the construction and the continuous reinforcement combine to give these safes a great power of resistance to damage by fall. The thickness of the walls varies from 3½ in. to 6 in., according to size and requirements. They are rather heavier than steel safes of equal size, a fact which in these days is rather advantageous than otherwise, as they are less easily removable by unauthorised persons.

The locking and bolting mechanism complies with all the usual requirements. It is arranged on the back of the door and is, therefore, protected by the thickness of the concrete of which the door is composed. The mechanism is mounted on drill-resisting plate secured to the concrete by embedded bolts. Large steel bolts secure the closed door to the safe on all sides, so that then it cannot be wedged open. In construction, great care is taken with regard to the materials. Standard forms and methods of procedure are adopted, and at some parts of the process a vibrating table is utilised to ensure the production of concrete of dense quality. The safes are finished by painting, rubbing down and varnishing, with nickel-plated fittings, and are equal in appearance to any steel safes on the market.

Similar construction is now adopted in the case of wall safes and strong-room doors, the latter being at present made in three standard sizes, ranging from 6¾-in. thickness of concrete for a door weighing 1 ton, to 20-in. of concrete in the case of the heaviest, which weighs 4 tons. The photographs given in Figs. 7 and 8 show the lighter pattern, while the drawings, Figs. 3 to 5, and the photograph, Fig. 6, relate to the 20-in. door, measuring 6 ft. 6 in. by 3 ft., and weighing 4 tons. The doors are set in reinforced concrete frames bonded into the surrounding reinforced concrete walls. The framing is shown very well in Figs. 3 and 7. The bonding bars, in practice, have hooked ends. The reinforcement adopted in the doors is similar to that used in the safes, modified as regards gauge, etc., while provision has to be made for the greater weight on the hinges. The door shown in Fig. 8 is one in a large London store; that illustrated in Fig. 6 is one in a bank in Paris. In both cases the doors are solid masses of reinforced concrete, the steel edges being provided for protection against rough usage, while the outside lip and the fire-lock rebate are arranged as in the safes. This will be clear from Fig. 5. The door frames are generally constructed at the works and built into the walls, though they can equally well be cast *in situ*, special moulds being available for this purpose. The doors swing on pivots hung on bars carried well into the mass of concrete of the door frame and in spite of their weight, turn very easily.

Doors of this character offer high security at a considerable saving in cost, while an additional advantage lies in the fact that the door may be constructed, if necessary, alongside its final position. This, in the case of these great weights, is an immense advantage in the case of alterations to an existing building when, to get a large and heavy door to the place where it is to be used, might require cutting away floors and walls. A reference has been made above to wall safes. These units consist of doors and door frames with bonding projecting from the latter to be embedded in the surrounding wall. These units are suitable for use in private houses, offices, etc., and can be set in position by ordinary bricklayers.

The safes and strong room doors referred to above are the invention of Mr. C. W. Thorig, of Zurich, all rights in this country being in the hands of the Fortis Reinforced Concrete Safe Company, Limited, for whom the safes are made by their associated company, the Empire Stone Company, Limited, at their works at Narborough.

CASTING TEMPERATURES.

AT a joint meeting of the Sheffield Branch of the Institute of British Foundrymen and the Sheffield Section of the Institute of Metals, held on Friday, the 11th inst., a most interesting paper on "The Influence of Casting Temperature on Aluminium Alloys" was read by Mr. F. H. Hurren, foundry manager of the Rover Company, Limited, Coventry.

The lecturer stated that, although the founding of aluminium was in its early infancy when compared with that of iron, it, nevertheless, occupied a very important position and was now an industry of considerable dimensions. The automobile and aeroplane industries were largely responsible for the great strides made in the use of aluminium castings, and in conjunction with the work for these industries many important investigations had been undertaken and much useful information obtained. Foundrymen were, to a large extent, indebted to the 'Light Alloys Research Committee' for their scientific knowledge of aluminium alloys; but at the same time useful work, which was recorded in technical journals, had been carried out by private persons.

The present average output of aluminium castings of the Rover Company's foundry amounted to 400 tons per annum. Some of these castings had to undergo a tensile test, some a water-pressure test, some an oil-pressure test, others had to withstand vibration, whilst some had to retain their strength at high temperatures. Analyses were regularly undertaken, but it was obvious that a measure of scientific control in the foundry was also essential. The lecturer considered that the casting temperature was of vital importance. It was well known that a casting poured very hot had a yellow or light brown skin. It was impossible to lay down a hard and fast rule, as the mass, thickness, type of alloy, and purpose to which the casting was to be put, all had an influence on the casting temperature. He was prepared to dogmatise to this extent, however, that for any one casting there was a short range of temperature at which the metal should be poured, to obtain the best result; and this temperature range could only be discovered by definite experiment in actual practice. The composition of the alloy was an all-important factor, and even a comparatively small change in the make-up of the metal charge had a decided influence on the casting temperature.

In a paper read by him in Birmingham in March, 1917, went on the lecturer, the following statement was made: "By proper attention to casting temperature, it does not matter what temperature the metal has attained, nor how long it has remained, in the furnace; equal results may be obtained from metal which has been melted with every care." Dr. Rosenhain and Mr. J. D. Grogan shared this view in a paper read before the Institute of Metals.* Their experiments were, however, conducted on commercially pure aluminium only. In the light of knowledge gained since 1917, and more especially during the last twelve months, the lecturer found himself compelled somewhat to modify his views, and these he proposed to give towards the end of the present paper.

A considerable amount of research had been carried out recently on the subject of ageing. This was a very important factor in production, and particularly applied in the motor industry, a period of at least four months often elapsing between the actual casting of the article and its *début* on the road as part of a finished car. The effect of internal strain was another important subject, and one on which no measurable data were obtainable.

* See ENGINEERING, vol. cxiv, page 394, 414.

The lecturer instanced castings carefully examined by two independent parties, placed in the stores without any rough handling, and found to have developed cracks some weeks later, owing, apparently, to internal stresses.

A series of exhaustive tests had been carried out by the author and the results were set out in the paper. The maximum temperature which the metal under review had attained in the furnace was given, and, unless stated to the contrary, the tests were made on metal which had remained in the furnace not more than 20 minutes after actual melting. All test specimens had either been sand or chill cast, $\frac{7}{8}$ in. in diameter in the rough, and, for the tensile test, turned down to 0·564 in. over 2 inches of parallel length. All bars had been produced under actual working conditions and the temperatures measured by means of a Foster base-metal couple immersed in the metal.

The most common troubles from which aluminium castings suffered were: (1) cracked and drawn places; (2) porosity; (3) fine pin-holes visible on machined surfaces; (4) sponginess; and (5) blow-holes. With the exception of the latter, these difficulties could be remedied by attention to melting practice and by paying due regard to the importance of casting temperature. Blow-holes were generally due to faulty moulding practice, but might be attributable to excessive oxidation during melting.

The paper mentioned tensile tests taken on sand-cast bars of L.8 metal (aluminium 87·90 per cent., copper 11·14 per cent., zinc trace). The bar cast at 800 deg. C., gave a "break" of 7·28 tons; that cast at 700 deg. C., 8·24 tons; and that cast at 600 deg. C., 8 tons. No yield point was visible, and the elongation was nil. The same metal, cast in chills, again gave a higher breaking stress when poured at a lower temperature and showed a small amount of elongation. Cast at 750 deg. C., "break" of 7·68 tons and no elongation; cast at 650 deg. C., "break" of 8·20 tons and 1 per cent. elongation. Again, no yield point was visible. The maximum temperature of the metal in the furnace was 960 deg. C.; this was higher than desired and was due to a mishap.

A number of results obtained on the "Y" alloy were then given, the tests having been carried out on the metal in the "as-cast" condition, and after heat-treating, quenching, and ageing. The lecturer mentioned that there was a distinct difficulty in casting "Y" alloy at comparatively low temperatures. Dr. Rosenhain, he stated, had recognised this and recommended a casting temperature of 750 deg. C., also that the metal in the furnace should not be allowed to exceed a temperature of 800 deg. C. He (the lecturer) had never attained anything like the remarkably high tensile results published by the Light Alloys Research Committee.

The results of an interesting double experiment were next discussed. A pot of metal (aluminium-zinc-copper alloy) was withdrawn from the furnace at 770 deg. C., and test-bars cast at 710, 670 and 640 deg. C. respectively. The pot was then replaced in the furnace, and the metal left to soak for 1½ hours. During that time the maximum temperature reached by the metal was 1,110 deg. C. After withdrawal and cooling, further bars were cast, again at 710, 670 and 640 deg. C. Tensile tests on both sets of bars were made and, on the whole, those cast normally gave rather better results. It could not be said definitely, however, that any harm was apparent. In the light of this, and many other experiments of a similar nature, the lecturer had been led to the belief that aluminium alloys suffered no ill effects by over-heating or burning, provided due attention were paid to casting temperature.

Further research, however, gave evidence which caused a modification of these views. Repeat impact tests on an Eden-Foster machine were carried out, and the total number of blows required to fracture each bar recorded. Of the two cast at 710 deg. C., that cast first required 18,976 blows to fracture, whereas after overheating only 10,780 blows were required. Of the bars cast at 670 deg. C., 22,458 blows were required to fracture the normally melted metal against 19,034 after overheating. Of the bars cast at 640 deg. C., that cast first stood 21,838 blows, but no results could be obtained from the bars cast after overheating, as no less than three bars were found to be unsound on turning. In each case the bars cast at 710 and 640 deg. C. were sand cast, while those cast at 670 deg. C. were chill-cast. It was interesting to note, pursued the lecturer, that, once again, the better results were obtained at the lower casting temperature, as evidenced by the fact that the normal bar cast at 640 deg. C. withstood nearly 3,000 more blows than that cast at 710 deg. C.

It was apparent, from these results, that aluminium alloys *did* suffer from prolonged overheating, although in this case it was deliberate and excessive. In automobile work capacity to withstand severe vibration was an important point. Tensile tests on overheated metal showed little depreciation but its defectiveness was revealed by repeat impact tests.

In connection with further experiments on the "Y" alloy, the lecturer gave data which showed that after ageing for 14 days there was a progressive rise in breaking stress with reduction of casting temperature. Tables of repeat impact tests were then exhibited. It was pointed out that in the "as cast" condition the bars showed a progressive rise in resistance to fracture as the casting temperature fell, but that heat treatment apparently so altered the structure that the effect of casting temperature was lost. Heat treatment caused a big increase in the number of blows necessary to fracture, particularly in the bars cast at 720 deg. C. This bore out the statement of the originators of this alloy, viz., that a fairly high casting temperature was needed for satisfactory results to be obtained.

Repeat Impact Tests on "Y" alloy, chill-cast. Maximum Temperature of metal in furnace 790 deg. C. Repeat Impact Tests.

No.	Cast at	Blows to Fracture. As cast.	Heat Treated.
32	720 deg. C.	1,222	42,338
33	700 deg. C.	1,962	13,126
34	650 deg. C.	3,862	15,072

The lecturer then submitted several tables to demonstrate the effect of ageing on aluminium-copper-zinc alloy test-bars cast at different temperatures. The differences at first apparent decreased considerably with continued ageing, but, in the main, both before and after ageing, the general rule applied, *i.e.*, better tensile tests were obtained at the lower casting temperature.

Although hardness was not a very important function of aluminium castings, there were occasions where a knowledge of the hardness was desirable. The lecturer consequently concluded with a discussion of the Brinell hardness of flat strips ⅜ in. thick, cast at various temperatures, and aged for different periods. The conclusions arrived at were that the hardness progressively increased and that the time factor apparently eliminated variations due to difference in casting temperature.

That casting temperature had a profound effect on the physical properties of aluminium alloys was, in the opinion of the lecturer, fully exemplified by the figures given. For the production of good castings he could only generalise by saying that a mould should be poured at the lowest temperature at which a sharp casting could be obtained. The best practice was to determine, by the aid of a pyrometer, the exact casting temperature at which the best results were obtainable for each type of casting, and standardise the pyrometer as part of the regular routine of the shop. Chance methods of working should be abandoned. Overheating had been shown to be harmful, it was also wasteful of fuel; the aim of every foundry foreman should be, "moulds ready for the metal, rather than metal ready for the moulds."

NOTES ON NEW BOOKS.

That a great variety of treatment is possible in a subject which might be considered as having become stereotyped is evident from the perusal of three recent works on engineering drawing. The first of the series is a work entitled "*A First Course in Machine Construction and Drawing*," which Messrs. T. M. Naylor and W. Tattersall prepared for Messrs. H. F. and G. Witherby of High Holborn, London, and which has been published at 6*s.* net. In this book an endeavour is made to familiarise a young student with the methods of construction commonly adopted for various components of a machine. Sketches are provided on alternate pages, and the notes relating to them and comments on the design are given on those opposite. The subjects dealt with are representative, but although there are a few notes on drawing instruments and the principles of projection, no instruction is given on the actual layout of a drawing, which is evidently left to the instructor in the class. The volume will prove useful to the students for whom it has been prepared. "*The Engineers' Draughtsman*," by H. Varley, published by Messrs. George Routledge and Sons, Ltd., London, at 5*s.* net, shows quite a different outlook. In this work the endeavour is made to show in outline the governing principles that underlie draughtsmanship. The standpoint here is that of the actual draughtsman, and the routine work has been emphasised. In this book there is a very large part devoted to the actual use of instruments and the layout of drawings. Standardised components are accompanied by tables of dimensions. The organisation of a drawing office system and its working are discussed, the estimation of weights and costs is treated and a chapter is devoted to the training of a draughtsman. The work is thoroughly well done, and the book will prove of great value to any young draughtsman. The third book is of American origin. It has the title "*Engineering Drawing*," and was prepared by Messrs. H. H. Jordan and R. P. Hoelscher, of the University of Illinois. It was recently published in this country by Messrs. Chapman and Hall, Ltd., at 15*s.* net. The aim of the authors in this case is to present information relating to methods of projection, the processes of reproduction, the preparation of graphs for informative purposes, the conventions of drawing as applied to maps, general engineering, architectural and structural work, and in the preparation of patent office drawings. In this sphere the work is most comprehensive and thorough.

The publication, by university professors, of courses of lectures delivered to students often constitutes a useful addition to the literature existing on the branch of science dealt with as, amongst other things, it usually provides a well-chosen *resumé* of all the available data. A third edition of "*Conférences de Chimie Minérale* (*Métaux*), by Professor M. Guichard, of the Sorbonne, has recently been issued; it is published by Gauthier-Villars et Cie, 55, Quai des Grands-Augustins, Paris, under the auspices of the University of Paris, Old Science, Students' Association, price 30 francs. It is intended primarily for first-year students at the Sorbonne, which course would seem to correspond with the standard demanded by the Intermediate Examination of the B.Sc., London University. A general account of the occurrence, distribution, chemical properties and reactions, and utility of all the principal metals is given. Much useful ground is covered, the chemistry of the salts and compounds of the metals being especially well set out. When of practical value the alloy-forming properties of metals are fully dealt with and demonstrated by means of thermal-equilibrium diagrams and a few photo-micrographs; the notes on alloy steels are quite good. In addition to the more common metals, some space is devoted to radium and the radio-active elements; the rare-earth metals and their salts are also touched upon. The precious metals are briefly yet fully described; here, as elsewhere, the author gives his sentences full weight; he always seems desirous of condensing the maximum information in the minimum space. One or two sections are devoted to the laws and general principles of solution, thermo-chemistry and the like. The book closes with a discussion on the periodic classification, and it is interesting to note that the author is not at all convinced as to its real usefulness to the chemist.

Commercial motor traction has an interesting history, and for that reason the inclusion of a chapter on the subject in "*The Book of the Thornycroft*," by "Auriga" is to be welcomed. This volume, which was recently published by Sir Isaac Pitman and Sons, Ltd., at a price of 2*s.* 6*d.* net, shows how to run and maintain the War Office J-type and other lorries efficiently. Although written with special reference to a particular make of vehicle, it must not be taken for granted that the information given in the book has no bearing on the running of other designs. Indeed, there is much general information in the book, which will appeal to every user of commercial vehicles. The author claims exceptional experience as a war-time workshop officer, and afterwards was responsible for the upkeep of a very large fleet of commercial vehicles. It is clearly evident from the matter, that he has extended experience and that he has drawn fully from it in preparing the book. In the opening chapter the importance of systematic inspection and cleaning are emphasised. Commercial vehicles have become so reliable nowadays that many liberties are taken with them, and necessary precautions in their maintenance frequently neglected, until the presence of troublesome conditions due to neglect is indicated by a shut down. All the component parts of the Thornycroft are described in detail. Chapter III of the book is the one in which the historical sketch is given, and the experiences in the European War are drawn on largely to bring out various points. In this respect we note the author quotes freely from Major Strickland's observations on the design of the J-type motor. Costs of running and the organisation of driving staffs are subjects which are treated in detail, and the methods of keeping records which are described, will be of great service to all who are responsible for a fleet of motor vehicles.

In shaft governors the position of the mechanism and the reactions of the oscillating forces give rise to resistances which are, roughly, proportional to the speed of the governor and have a general damping effect. These resistances are the subject of an experimental and theoretical study by Dr. Ing. P. Watzinger, Professor of Engineering at the Technical High School of Trondhjem, Norway, and his assistant, Mr. Leif J. Hanssen, published under the title "*Der Regelvorgang bei Kraftmaschinen auf Grund von Versuchen an Exzenterreglern*," in a volume of 88 pages with 82 diagrams. [Berlin: Julius Springer; price 1·70 dollars.] The experiments were made by the authors in conjunction with Mr. Leif Soelsnaes, first on the compound engine

and the tandem portable engine, of R. Wolf, at the College, and then with a special eccentric governor of high inertia fitted to a vertical engine provided with piston-valve gear. Professor Watzinger finds that the resistances mentioned absorb a very essential portion of the regulating force of the governors, which is usually very much larger than the forces required for the acceleration of the masses, and that the calculations can be simplified by the introduction of a term which he designates "limit value of the degree of non-uniformity." The conditions of regulation will be the more favourable, it is concluded, the smaller the radial excursion of the governor weights relative to the requisite adjustment of the setting of the eccentric. The general considerations and the calculations of the work capacity of the governor would be applicable also to other than eccentric governors, since such reactions will rarely be altogether excluded in a sensitive governor.

The number of books which have recently appeared on boiler-house and power-station practice is significant of the interest of the subject, and their cumulative effect can hardly be other than the improvement in operating methods. It is, however, sometimes difficult to decide exactly what class of reader the author hoped to appeal to, a question which naturally arises when looking through "*The Supervision and Maintenance of Steam-raising Plant*," by Charles A. Suckan (London, 1924, Ernest Benn, Limited, price 36*s.* net). This is a handsome book thoroughly well printed and illustrated as befits its price, and the systematic contents list, with its sections and subsections, indicates the intention of the author to fill in, in orderly fashion, a framework covering the large field which is indicated by the title. The aim was a good one, but possibly the task was too great. The net result, so far as it can be expressed briefly, is a work mostly devoted to illustrated descriptions of boilers and power-house equipments, but containing nevertheless a good deal of sound and practical advice on details. A very large number of the illustrations are superfluous, being either mere pictures, or reproductions of illustrations already rendered sufficiently familiar by catalogues and technical literature. We have, for example, four large photographs of the result of boiler explosions, the only object of which can be "to make our flesh creep." Again, it is difficult to think that a man who wants to know what a Cochrane boiler would look like if part of the shell were broken away, or who needs enlightenment as to the perspective appearance of a Green's economiser, or who requires illustrations to tell him how the damper counterbalance looks when it hangs down in front of a Lancashire boiler, would buy so expensive a volume as the present for the information. There is, however, a great deal of useful information in the book. The author has an irritating method of referring, apparently, to everyone in charge of boilers as the "engineer-chemist," a term which must be used hundreds of times throughout the volume, and we occasionally come across somewhat academic ideas such as "to set a boiler in a limited space . . . under difficult conditions is a job for specialists requiring . . . a thorough acquaintance with stream-line motion."

The well known German Year Book "*Nauticus*" is written by several authors, and is divided into many sections, on political economy, naval technics, the German navy before and after the war, foreign navies, air forces, &c., closing with statistical chapters. The war and its results, the peace treaties and their "iniquity" from the German standpoint, are subjects which are entered into in detail. We find that "the German shipping trade has never been aggressive and has never stepped in to underbid freight rates which were considered the right ones." In his modesty, one writer quotes from British and American sources, and says that "Germany has always applied the very best colonising methods." In one instance "German colonists learned the easy Swaheli language, this having the advantage of relieving them from the necessity of hearing the German language mutilated by negroes and, what was more important still, of relieving them from the obligation of using the childish and grotesque pidgin-English resorted to in the Tropics." We have always wondered whether it had ever been possible to teach an East or South-West African negro to say "1888" in German. We also find it stated that "South-West Africa was always sparsely populated, and the negro population was decimated by continual feuds with the cunning and predatory Hottentots." Further, the peace treaties "are entirely built upon present power on the one side and powerlessness on the other . . . . and the length of life of these treaties will depend upon how long folly and lies can triumph over reason and truth." It is good at this point to reflect upon Germany's peace terms as they were laid down by a member of the Prussian Upper House, Count von Roon, in May, 1918. Covert attempts are made to divide the Allies, and future wars are hinted at. The above will give an idea of the contents of "*Nauticus*." We need not refer to the statistical portion. The rumour to the effect that the future German submarines are to be known as of the "K" class, having names beginning with that letter, and which have become very familiar to the Allied troops and the world in general, is not confirmed by the book, and remains, no doubt, an idle rumour only. The present edition is the 1923 edition; the last preceding one was dated 1914. The price, on issue, was 25,500 marks. The publishers are Messrs. E. S. Mittler and Son, Berlin.

INDUSTRIAL NOTES.

WITH further reference to the difficulty between the railway companies and the Associated Society of Locomotive Engineers and Firemen, it is now reported that about 20,000 members out of the total number of 60,000 did not record their vote, although they had every facility for doing so, the date on which the ballot papers were returnable having been extended. The statement to the effect that the vote shows a majority of six to one against acceptance of the awards given by the National Wages Board (see page 43 *ante*) is therefore fallacious.

In a statement issued by the railway companies stress is laid on the fact that there is no power to impose the awards of the Board either on the men or on the companies, but neither has ever before refused to accept them. The decisions were signed by the representatives of all three unions. The proposals of the companies put before the Board would have saved them about 4,000,000*l.*; the result of the awards will be a saving to the companies of barely one-eighth of that total, but they decided nevertheless to abide by the Board's decisions. The National Union of Railwaymen and the Railway Clerks' Association, as previously stated, also agreed to abide by them. The companies add that the basis rates of engine drivers were fixed in 1919 at 114 per cent. over the pre-war average, those of the firemen at 140 per cent. over, the general average for all other grades being about 100 per cent. over. The present findings of the Board do not affect the basis rates of any employee; enginemen will continue to enjoy their favoured position, and even when the awards of the Board come into operation the earnings of the comparatively small body of mileage men will remain substantially at the same basis rates.

The situation was considered at a meeting last Monday of the General Council of the Trades Union Congress, but without any satisfactory result, judging from the following statement issued after the meeting: "The Council, having had the benefit of the views of railway trade union representatives on the whole situation, decided to adjourn pending further developments, and instructed the secretary to summon the London members of the council to act as an emergency committee if and when it is deemed desirable." The fact that the General Council have not issued a resolution in favour of the railwaymen's contentions appears striking in the circumstances. The Associated Society of Locomotive Engineers and Firemen are thus left to bear alone the responsibility for their action, but conversations are taking place between representatives of the Society and leaders of other unions.

Figures of the miners' ballot which have been made public during the last few days on the question of terminating the National Wages Agreement, point to a large majority in favour of its termination. This would not result in an immediate strike of the miners throughout the country. Following the adverse ballot—if it is adverse as may be expected—the miners' executive are to give three months' notice to the owners. In the meanwhile negotiations would be carried on with the latter with a view to modifying the existing agreement or arriving at a new one satisfactory to both parties.

The Blackburn Weavers' Protection Society in their half-yearly report recently issued, state that there are signs of improvement in the cotton trade. They add, however, that the violent fluctuations in the price of cotton render the position difficult; should trade steadily increase they are afraid that a shortage of cotton would result in a serious loss to Lancashire. The society express the hope that something will be done quickly to extend cotton growing in different parts of the Empire, with a view to decreasing our dependence upon the United States for our raw cotton supply. We take this opportunity for expressing a similar hope; many British Possessions are admirably suited to cotton growing.

The National Wages and Conditions Council for the Building Industry have decided to increase the wages of craftsmen by ½*d.* per hour, from February 1, in accordance with the sliding scale agreement, which provides that wages rates are to be adjusted half-yearly by that amount for each variation of 5½ points in the total cost of living. The resolution passed by the Council reads as follows: "That on and from February 1, the rates of wages payable to craftsmen shall be increased by ½*d.* per hour, and that the hourly rates payable to labourers shall be not less than 75 per cent. of the craftsmen's rates, calculated to the nearest farthing." The Council also agreed to re-grade a number of towns, this resulting in an extra increase, under the sliding scale, over and above the ½*d.* to men in these towns.

The elimination of the 12-hour day by Chicago district mills and blast furnaces has been much more rapid than was originally expected, says *The Iron Age*, New York. At first it was estimated that a complete change to the new basis of operations could not be possibly effected for a year. As a matter of fact, however, the 12-hour shift has been entirely eliminated in all United States Steel Corporation plants, and with very few minor exceptions is now a thing of the past in other steel works also and in merchant blast furnace plants. In the case of the Inland Steel Company, the change means an increase of 27 per cent. in the number of men employed. Chicago district producers are unwilling to commit themselves as to the increased cost of production attributable to the elimination of the 12-hour day. Most works state frankly that the men prefer the shorter shift, but one important producer is of opinion that fully one-half of his men would prefer the 12-hour day because of the higher total daily earnings. The most convincing testimony to the fact that the men prefer the shorter day is the experience of the Wisconsin Steel Works, South Chicago, which has been on a three-shift basis for some time past.

The Federation of British Industries has addressed a letter on behalf of the Traders' Co-ordinating Committee, to business firms throughout the country, appealing for contributions to a fund to enable a case to be made on behalf of the users of the railways, should it prove necessary to deal with the railway companies' proposals by litigation. The committee was constituted about three years ago and the work it has already accomplished has been of the greatest possible value to all traders. The inquiry into the basis of the standard charges is shortly to be opened before the Rates Tribunal. The railway companies will instruct the best counsel they can secure, and the committee feels that the traders should be similarly represented, having regard to the very great interests at stake. They must know beforehand how the expense will be met. The committee has therefore decided that all who are in any degree users of the railways should be invited to contribute to a fund for the purpose in view.

The bulletin recently issued by the British Chamber of Commerce for Italy gives publicity to Italian strike figures during the period from November 1, 1921, to October 31, 1922, as compared with those of November 1, 1922, to October 31, 1923, under the Fascista regime. The figures are as follows, in regard to industrial strikes:—Former period, 643 strikes; 479,045 strikers; 6,892,795 days lost. Fascista period, 154 strikes; 52,254 strikers; 246,125 days lost. The figures concerning agricultural labour are given also; the days lost during the former period numbered 443,598, as against 850 only during the Fascista period.

Representatives of the Transport and General Workers' Union and of port labour employers met together last Wednesday to consider the men's claims as set forth on page 11, *ante*. The men were informed that in the present condition of trade it was impossible to grant any increase in time work wages. The men's other claims—a corresponding increase in piece work wages and a guaranteed week—were not gone into. The case of the National Amalgamated Stevedores has not yet come forward.

PERSONAL.—The Citroen Gear Company, Limited, have removed their offices from 22, Buckingham Gate, S.W. 1, to Citroen Building, Brook Green, Hammersmith, London, W. 6, where future communications should be addressed.

BRITISH IRON AND STEEL PRODUCTION.—The National Federation of Iron and Steel Manufacturers states that the production of pig-iron in December amounted to 626,900 tons compared with 598,200 tons in November and 533,700 tons in December, 1922. The number of furnaces in blast at the end of December was 204, an increase of 5 during the month. The output of steel ingots and castings fell, owing to the Christmas holidays, from 749,500 tons in November to 653,300 tons in December. The December output brings the production of pig-iron for 1923 to 7,438,500 tons and of steel ingots and castings to 8,488,900 tons compared with 4,902,300 tons and 5,880,600 tons respectively in 1922 and 10,260,300 tons and 7,663,876 tons in 1913.

A PETROL ENGINE FOR WIRELESS TELEGRAPH EQUIPMENT.

DURING the past few years Messrs. J. W. Brooke and Co., Ltd., of Adrian Works, Lowestoft, have supplied many small petrol engines for the driving of dynamos for wireless telegraphy. In some cases peculiar circumstances had to be allowed for in the design, as an example illustrations are provided on this page of an 8-10 h.p. petrol motor of which type a number were recently supplied to a foreign government. These plants had to be transported for a considerable distance on camels, and, therefore, after the works tests had been conducted by the inspecting engineer, each set was completely dismantled and the parts packed in separate cases, of which the total weight did not exceed 150 lb., and arranged so as to permit the balancing of the loads on the camel's back. The design of the engines is free from anything of the nature of complication to permit of this method of transportation and reassembly. It should be mentioned that the arrangement of the valves on each side of the engine was dictated by the purchasers, who desired to have engines of which the parts were interchangeable with those of a number of sets they purchased a few years ago. The makers have adopted side by side valves as well as forced lubrication in their new standard design.

The general arrangement of these complete power units is shown in Fig. 1, while the drawings given in Figs. 2 to 5 serve to show the construction. The engine is of the two-cylinder commercial type, and mounted on a cast-iron bedplate, which is extended to carry an outside bearing beyond the flywheel and the V-type pulleys. The drive to the dynamo is effected by means of Whittle belting, and it is for this purpose the grooved pulleys are required. An auxiliary drive of a similar nature, is arranged at the engine side of the flywheel. At the extreme end of the shaft a tachometer is mounted on a bracket extending from the pedestal of the bearing. This provision is made to facilitate the check of the control of the engine, as constant speed of running is an essential requirement. Lubrication is effected by the drip feed method, but there is an auxiliary arrangement for an exhaust pressure fed system. The engine has two cylinders of $3\frac{3}{8}$ in. bore and $4\frac{1}{4}$ in. stroke, and works on the four-stroke cycle, running at a normal speed of 950 r.p.m. The crankshaft is of nickel steel, provided with two long main bearings with white metal linings. Hardened steel bushes are fitted into the stamped connecting rods for the accommodation of the gudgeon pins, and die-cast white metal bearings are provided for the big ends. The valves are made of nickel steel and provided with long guides, which are renewable. The valve tappets are adjustable and have hardened rollers at their ends. The cams are made solid with the camshaft and the drive is effected by gears. At one side of the engine the camshaft drive is arranged to operate a spring-controlled governor, which works a throttle valve in the induction pipe through a simple-lever system shown in Fig. 1. On the other side a drive is taken to the jacket water pump, which is of the eccentric drum type, and also to the magneto.

LOW TEMPERATURE CARBONISATION.—The Power Gas Corporation, Limited, of Stockton-on-Tees have been awarded a contract for the installation of their new system of Low Temperature Gas Producer Plant with By-product recovery, at the Springfield Paper Mills of Messrs. William Tod, Junior and Co. (1923), Limited, of Polton, Midlothian. The plant will gasify about 56 tons of coal per twenty-four hours, the gas to be used for boiler firing. The installation includes coal-handling plant, sulphate of ammonia recovery plant, and tar dehydrating plant. The Power Gas Corporation, Limited, have also secured an order for drawings of a similar plant, of approximately the same capacity which is to be erected abroad. The gas in this case also is to be used for firing boilers.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—In a paper read before this Institution on the 11th instant, Mr. R. L. Howard-Flanders gave a very interesting account of the work of some of the pioneers in the development of aviation in this country. He dealt first with the work of Mr. A. V. Roe carried out with a triplane on the Lea Marshes in the summer of 1909, and afterwards with that of the little band of experimenters, including the author, who congregated at Brooklands. The various machines employed at this aerodrome and their performances up to the period of the military trials of 1912, were described in some detail, and although the results seem meagre enough in the light of modern achievement, it is evident that they played a by no means unimportant part in the development of the Science. The author did not refer to his own work in this direction, but mentioned that the first Marconi wireless messages to aircraft were transmitted from and received on his monoplane in April and May of 1912. This, he stated, was the first instance of wireless reception in the air in Europe and the first transmission from an aeroplane in flight over England.

PETROL ENGINE FOR WIRELESS TELEGRAPHY.

CONSTRUCTED BY MESSRS. J. W. BROOKE & CO., LIMITED, ENGINEERS, LOWESTOFT.

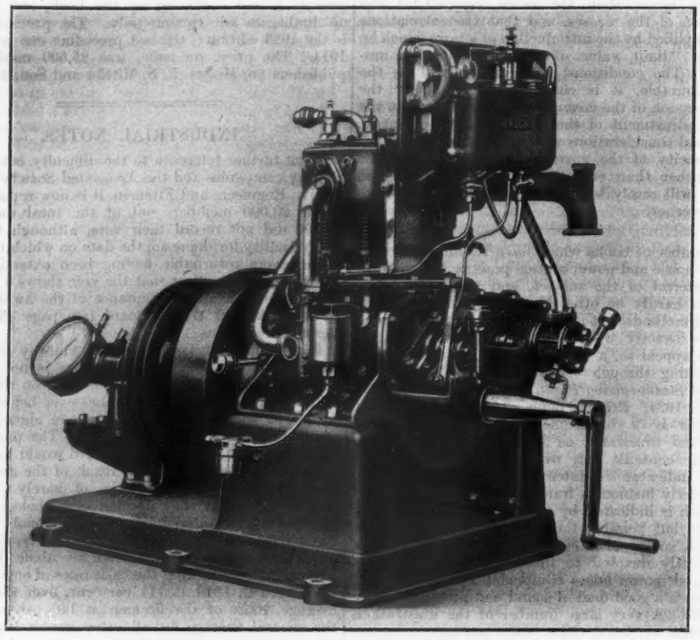
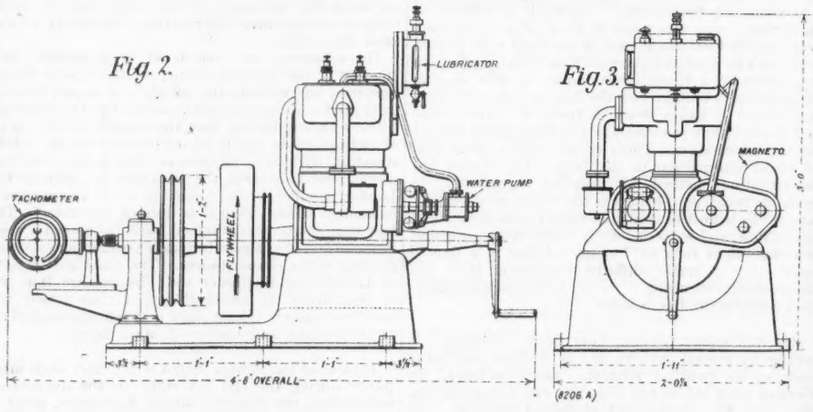
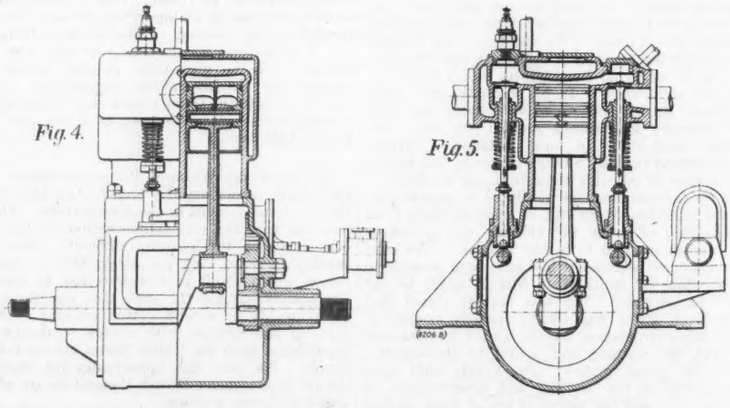


FIG. 1.





THE SOCIETY OF NAVAL ARCHITECTS (JAPAN).—The autumn general meeting of the Society was held on November 11 at the Lecture Hall of the Imperial University, Tokyo, and the following papers were read:—(1) "On Apparent Moment of Inertia of the Vessel due to Rolling." By K. Suyehiro, D.Eng., member. (2) "The Skin Frictional Resistance and the Law of Comparison." By S. Shigemitsu, B.Eng. (Tokyo), member. (3) "The New alloy for the Turbine Blades." By I. Iitaka, B.Sc. (Tokyo), visitor. (4) "On the Effects of the Earthquakes on Industrial Works." By J. Takenaka, B.Eng. (Tokyo), member.

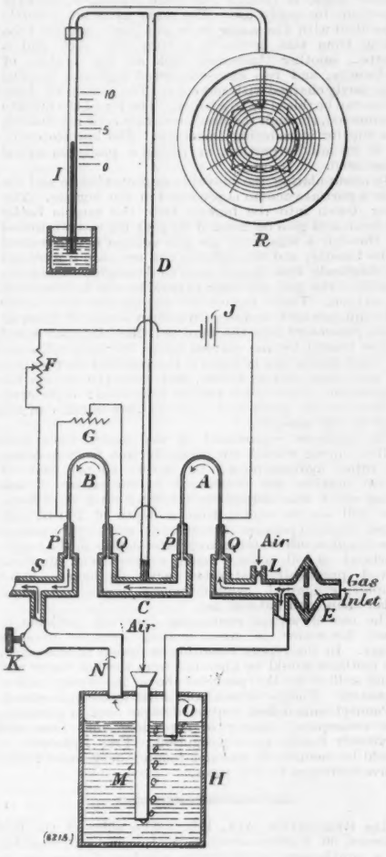
THE UEHLING CARBON MONOXIDE RECORDER.

THE complete combustion of pure coal should yield only carbon dioxide and water vapour, more or less diluted with atmospheric oxygen and nitrogen. The most easily determined of these constituents are the water and carbon dioxide. If we could burn carbon with no more than the theoretically necessary supply of air, the flue gases should contain 21 per cent. of CO_2. Practically, a certain excess of air must be provided, and when about 1·5 times the theoretical air allowance is made the gases would contain 12 per cent. of CO_2. When a smaller CO_2 percentage is found, there will be too much air, complete combustion assumed. But the combustion may be incomplete, owing to a deficiency of air; carbon monoxide CO may be formed and escape up the chimney before giving up the full heat energy of the carbon to the gases that the complete combustion to CO_2 would have yielded. For an efficient control of a coal fire we should therefore have a continuous record of any CO present in the flue gases, in addition to the continuous CO_2 record which we can now obtain by means of various apparatus. But CO cannot so conveniently be absorbed in recording apparatus as CO_2 is absorbed by caustic soda. There are absorbents for CO, such as the alkali metals and solutions of cuprous chloride in either hydrochloric acid or in ammonia. The solution of cuprous chloride in hydrochloric acid is used for gas analysis in apparatus of the Orsat type; but these volumetric laboratory apparatus are neither continuous nor recording, and can only deal with small gas samples at intervals. The acid or ammonia vapours, moreover, are disturbing factors. Hence combustion of the CO to CO_2 and other analytical means are relied upon, and CO recorders have so far little been used.

The continuous CO recorder which we illustrate in the annexed diagram has been developed by the Uehling Instrument Company, of Paterson, New Jersey, United States, and can be used either in connection with the CO_2 recorder of that firm, which we described on page 626 of our issue of May 20, 1921, or mounted separately. The general principle of the two apparatus is the same in so far as a constant flow of the flue gas through the apparatus is maintained by aspiration; but in the CO apparatus there is no absorbing medium, and the record is obtained by means of a pressure gauge. The gas flows continuously through two platinum tubes of inverted U-shape and small bore, A and B, which are electrically heated; the glass tubes P and Q insulate the platinum from the rest of the circulating system. The gas enters at E, and there is an auxiliary air inlet at L. Any CO or other combustible gas (methane or other hydrocarbons, and also hydrogen), present in the gas will be burnt within the tube A raising, the temperature of that tube in proportion to the amount of the actual secondary combustion. The heated and proportionately expanded gas passes through the chamber C into the second platinum tube B, which acts as compensator. The hotter the tube A becomes, the smaller will be the amount of gas entering the chamber C. The outlet suction does not vary; a decreasing flow of gas through A therefore results in a greater partial vacuum in C. The variation of the suction in chamber C will thus be a measure of the additional heat units given to the gas by the secondary combustion in A; the recording gauge, which may be placed anywhere, is therefore joined to the chamber C, the connection being established by the tube D. The recorder R can be calibrated in per cents. of CO or in heat units. The indicator I, branched off from D, is mounted for convenient observation by the stoker.

The electric heating may be effected by direct or by alternating currents. The diagram shows a storage battery, which should be capable of supplying about 40 watts for this purpose. The battery feeds the heating circuit through the resistance F. The second tube B, it will be noticed, is shunted by a further resistance G by means of which the temperature of B can be adjusted within a few degrees of the initial setting. Constancy of the battery potential is not required, because the two tubes, electrically in series, are heated to the same degree by the same current and will cool equally if the battery should run down. The suction in C, on which the working of the whole instrument depends, is only affected by the actual temperature difference between A and B, but not by the temperatures themselves.

When the CO recorder is coupled with the CO_2 recorder, which we described on the former occasion, the device then mentioned for maintaining the constant flow can be utilised for both the instruments. In separate installations the CO recorder will further require the suction regulator H of our present diagram. Two pipes, M and O, extend into the water of the tank H; M goes nearly to the bottom of the tank. The outlet of O is exactly 6 in. above the outlet of M if a suction of 6 in. of water is to be maintained. The pipe O is joined to the gas inlet near E; a third pipe N, passing through the top plate of H, connects the air in the tank H above the water with the aspirator outlet S through the needle valve K. The rate of flow depends upon the setting—which need not be very exact—of the needle valve K. As long as air can bubble up from the outlet of M and gas can bubble up from the outlet of O, pipe M will be full of air, the water level will be at less than atmospheric pressure, and the bottom of O will be under the desired suction of 6 in. of water. This suction will be maintained all the way back to the first platinum tube A, independent of any change in the gas pressure on the inlet side of the opening E caused by any draught variations in the flue. Make-up water is supplied through M; the level in H does not matter as long as the outlet of O is submerged.



The arrangement resorted to for creating the primary fixed suction at S, by means of a steam, water or air aspirator, and other accessory parts, are of the kind which we noticed in the previous article. Fouling and corrosion of the gas line is prevented by the pyro-porous filters, drying and desulphuring devices, of the firm; the air path L also needs filter protection. The platinum tubes A and B are provided with glass covers, not shown in the diagram; these tubes are said to be unaffected by the conditions of working. As little as 0·1 per cent. of CO or equivalent can be indicated, we are informed, and the instrument is speedy and sensitive in action. The recorder does not distinguish between unburnt CO and unburnt hydrocarbons or hydrogen, of course. That matters little, however, as the object is only to control the fire in such a way as to avoid heat losses through escaping combustible products.

THE UNIVERSITY OF LEEDS.—This University has issued a programme of special courses for the session 1923–24 of the Department of Coal Gas, Fuel Industries, and Metallurgy. Particulars of the courses and indication of the terms can be obtained from the Registrar.

THE AMERICAN MOTOR-CAR INDUSTRY.—According to *The Iron Age*, New York, figures compiled by the Department of Commerce show that during the first eleven months of 1923 the output of passenger automobiles amounted to 3,361,090. During the same period the output of lorries aggregated 348,330, making a total of 3,709,420 passenger automobiles and lorries for the eleven months. On this basis it is estimated that the total production for the year will be about 4,000,000 vehicles.

"RAPID" SCREWING MACHINE.

A SERVICEABLE type of screwing machine, the design and manufacture of Messrs. Scott Bros. (Keighley), of Albion Works, Keighley, which may either be mounted on a cabinet base or used as a bench tool, is illustrated in Figs. 1 to 6, page 80. In the two views, Figs. 1 and 2, the machine is arranged for power or hand driving and with the use of either a solid or a chaser type of die. The machine was designed to cut rapidly and accurately Whitworth threads on bolts from ¼ in. to 1¼ in. diameter and also to deal with gas and steam pipes of sizes ranging from ⅛ in. to 2 in. bore.

When a power drive is fitted, a three-cone pulley is installed and the equipment includes an extra pair of wheels which make six speeds of working a possibility. Otherwise the machine is similar to the hand machine of which the details of construction are shown in Figs. 3 and 4. In this case there are three speeds provided for, and in the illustrations the use of the third speed is indicated. Removal of the clutch and the operating handle from the position shown and its replacement on the intermediate shaft above or directly on the end of the main shaft (see Fig. 3) is all that is necessary to alter the speed ratio and obtain the second and first speeds. The clutch is designed so that it may be quickly accommodated in any of the three positions. The drive to the die is effected through a bevel wheel and pinion. The circular adjustable dies have a standard taper on one side and a short taper on the other, to allow of their use in screwing work right up to a shoulder whenever that is necessary. The vice has two jaws mounted so that they may be made to approach or recede from one another and yet always have the centre of their gap in the centre line of the spindle. This is accomplished by the adjustment of a heavy screw with both a right handed and a left-handed thread. The slides are accurately machined and scraped and form a wide bearing for the saddle.

An elevation and a section of the chaser die, shown in Fig. 2, fitted to the hand-operated machine, are given in Figs. 5 and 6. On the end of the hollow spindle there is a stepped flange. Four radial grooves are cut through the part of small diameter, for the accommodation of the chasers. A ring which may be revolved to obtain any desired setting of the distance between the cutting faces of the chasers, is accommodated on the smaller diameter part of the flange, and its outside diameter is the same as that of the wider part of the flange. The chasers have curved notches cut on them, which engage with projections inside the ring. In Fig. 5, which shows the ring in place on the flange, may be seen the form of the curved surfaces and the ridges, which are used to cause the chasers to approach or leave one another as the ring is turned. The setting is easily effected for the nuts on the studs, which pass through slots in the flange and are used to grip the ring to the flange when set, may be slacked off and the ring turned to suit the requirements. From Fig. 2 it will be noticed that the ring has a graduated outer edge to facilitate the setting. A cover plate is bolted to the front and is removable to replace the chasers.

YEAR BOOKS AND ANNUALS.

The Textile Recorder Year-Book, 1924.—This publication, which goes by the unpretentious name of "year-book," is in effect a very complete encyclopædia on all that appertains to the textile trades. It deals with the raw materials and, in separate chapters, with cotton; hosiery manufacture; woollen and worsted; flax, jute, and ramie; raw, waste, and artificial silk; whilst chapters of general interest cover fuel economy, works' organisation, patents, &c. It not only appeals to merchants of all classes of textile materials and manufactured goods, but also, and to a very large extent, to textile works owners, their engineers and employees, all of whom will gather from its pages a large amount of interesting matter. Other engineers—and their number is a large one—who are called upon to specify occasionally for plant connected with the textile trades will also find it a useful guide. The book measures 7½ in. by 5½ in. and contains over 800 pages of carefully indexed subject-matter. It is compiled and edited by Mr. Frank Nasmith, and is published at the low price of 7*s.* 6*d.* net, by Messrs. John Heywood, Limited, 121, Deansgate, Manchester, and 20–22, St. Bride-street, London, E.C. 4.

Austrian Mining Annual, 1923.—The title of this year-book for 1923, the fourth annual edition, is "*Mitteilungen ueber den oesterreichischen Bergbau.*" It is compiled by the Federation of Austrian Mine-owners, and can be obtained, at the price of 60,000 Austrian crowns, from the Verlag fuer Fachliteratur G.m.b.H., 9, Eschenbachgasse, Vienna I. It contains, in a large number of tables, information on the country's

coal and other mines, their plant, number of men employed, output, accidents, and gives the names of owners, managers, engineers, &c.

Clubs.—A book for the present year, the thirty-second annual edition, giving the list of English clubs in London, the suburbs and provinces, and in all parts of the world, is edited by Mr. E. C. Austen-Leigh, and is issued at the price of 7*s.* 6*d.* net by Messrs. Spottiswoode, Ballantyne and Co., Limited, New-street Square, E.C. 4. The information includes the address, the date when established, membership, fees, names of secretaries, and objects of the clubs.

Almanacks and Calendars.—Monthly tear-off calendars have come to hand from the International Construction Company, Limited (successors to Julian Kennedy, Sahlin and Co., Limited), 56, Kingsway, W.C. 2; Messrs. Burton, Griffiths and Co., Limited, 64 to 70, Vauxhall Bridge Road, S.W. 1; Messrs. John and Edwin Wright, Limited, manufacturers of steel ropes, Birmingham, London, Liverpool, Sheffield and Cardiff, this calendar being for four years, 1924 to 1927; also a calendar for the year from Messrs. Joseph Westwood and Co., Limited, bridge builders and constructional engineers, Napier Yard, Millwall, E.

THE OPTICAL SOCIETY.

AT a meeting of the Optical Society held at the Imperial College of Science and Technology on Thursday, January 10 last, the following papers were presented and discussed:—

"*The Relation between Aperture, Axial Thickness, and Form for a Single Lens,*" by T. Smith, M.A., F.Inst.P. The determination of the thicknesses to be given to lenses of known shapes to enable a given aperture to be attained is a problem which occurs frequently in computing lens systems. When ray tracing is the method of design employed any convenient solution may be used—for example, the direct graphical method of drawing a section of the lens on a convenient scale with the required curvatures, the centre of the second surface being found by striking intersecting arcs of the given radius from points on the first circle whose distance apart is equal to the assigned aperture, and measuring the axial thickness on this diagram. If algebraic methods of calculation are used, an algebraic solution of the problem is necessary. Such solutions assume the simplest form in connection with the converse problem of finding the maximum aperture which is attainable with a given thickness. From the point of view of the development of algebraic methods it happens that this simpler converse problem is unimportant, but solutions, both exact and approximate, may be used as a means of constructing solutions to the real problem. In the paper a comparison is made between the exact and various approximate expressions connecting the attainable aperture and the axial thickness for simple lenses of various shapes.

"*The Determination of Aberrations as Expressed in Geometrical Optics from the Indications of the Hilger Interferometer,*" by J. W. Perry. The paper gives and illustrates methods of deriving from the indications of the Hilger lens-testing interferometer quantitative expressions of the aberrational defects of a lens system in terms of the departure from ideally perfect focal ray-union, as measured longitudinally at the focal plane and as obtained in the course of computation of an objective. Replicas of the two Galileo telescopes at Florence were exhibited by the kind permission of Col. H. G. Lyons, F.R.S., Director of the Science Museum, and were described by Mr. D. Baxandall. These interesting copies, which have been added recently to the Collections in the Museum, were made in Florence through the kindness of Professor A. Garbasso, Director of the Museo di Fisica. As a result of a suggestion made by Professor Geo. E. Hale when in Florence in May last year, both of the telescopes, as well as the famous broken object-glass of Galileo, have been tested by Professor G. Abetti and Professor V. Ronchi. The former attached the instruments to the Amici equatorial at Arcetri, and tested them by observations of sun-spots, lunar craters, Venus, Jupiter, Saturn, and certain double stars. Professor Ronchi made measurements and tests in the laboratory. Mr. Baxandall gave a short account of the results obtained, which are given in detail in two papers published in the Italian periodical L'Universo.

ACCURATE WATCHES.—The record for the highest accuracy in watches has again been broken. The official tests recently completed at Teddington, give the highest place to a Solvil watch made by M. Paul Ditisheim of La Chaux de Fonds, Switzerland. This watch gained 97 marks out of a theoretically possible total of 100, representing an absolutely perfect watch. It is estimated by experts that on account of variations in humidity and atmospheric pressure and also in the recording instruments and the observers themselves, no watch could in practice gain more than 98·5 marks. The achievement of 97 per cent. is, therefore, all the more remarkable, especially as the successful watch is a plain lever going-barrel "deck watch" of robust construction. In 1902 the highest figure attained was 92·7 marks. This level was surpassed by M. Ditisheim in 1903 with 94·9; and by successive stages he improved the results to 96·9 in 1919, holding for 21 years the record among more than 18,000 chronometers tested in the International Trials.

GASES IN GROUND WATERS AND OIL-PROSPECTING.

RECENT researches conducted by the United States Bureau of Mines show that the analysis of the gases dissolved in underground waters may assist the geologist and the prospector in the search for oil. All water traversing an oil sand or gas sand will absorb some of the hydrocarbon vapours, and will carry them up to the surface. In worked oil fields all water will more or less be contaminated with hydrocarbons, and their discovery would be of no value; but in new ground to be explored and in progressive drilling the water should be tested at intervals to ascertain whether oil-bearing strata are being approached. The glass apparatus for this purpose which G. W. Jones, W. P. Yant and E. P. Buxton describe in a report issued by the United States Bureau of Mines (Investigation Report, Serial Number 2553) is though not quite simple, sufficiently convenient for ready use. The main parts are a bottle to be filled with the water to be analysed; a glass tube leading from this bottle to a three-way cock and a burette; another three-way cock at the bottom of the burette, and two inter-connected aspirator bottles, to be partly charged with mercury. The second of these bottles can be raised up to a bench. The top of the burette is connected, through the first three-way cock mentioned, to a cup for introducing chemicals. The burette opens out in its middle portion, in which a platinum spiral is mounted.

By manipulating the movable aspirator bottle and the cocks a partial vacuum is produced in the burette. The water drawn into the burette from the sample bottle will froth and give off most of its gas; the water is forced out through a side tube, the gas volume is determined in the burette, and through the cup are then introduced the chemicals, first caustic soda to determine the carbon dioxide in the gas, and then pyrogallic acid to determine the oxygen. These liquids are washed out with water and sulphuric acid, and oxygen is then admitted (from an ozone generator) into the burette; the platinum spiral is now heated by the current from four dry cells, and the combustible gas is burnt; the combustion products are again analysed as before, and from the results the composition of the gases can be estimated; 5 per cent. or more of the gases and vapours may remain in the water in this analysis.

The analyses reproduced in the report show that shallow spring waters are generally free from methane and other hydrocarbons; but up to 40 per cent. of carbon dioxide was discovered in the water of one spring which was utilised for watering stock on a farm. Two well waters coming from a depth of 200 ft. contained about 20 per cent. of methane; more hydrocarbons were found in salt water from greater depths in the neighbourhood of oil wells. Some waters from Montana proved practically saturated with methane; other samples suggested contamination with petroleum rather than with natural gas.

The use of waters containing dissolved methane in closed hot-water or steam-heating systems involves danger. In the report attention is drawn to this point. The methane would be liberated from the hot water and would collect in the pockets above the water, unless vented off. The gas drawn from a hot-water pipe system in Pennsylvania indeed contained 80 per cent. of methane. The consequent danger of explosions and fires had previously hardly been recognised. Free hydrogen, it should be mentioned, was not found; acid water might evolve hydrogen in iron pipes.

GAS REGULATION ACT, 1920.—The office of the Gas Referees, 66, Victoria-street, S.W. 1, issued on December 15 a supplement modifying a number of passages in their general notification, which appeared on June 15 last.

UNIVERSITY OF LONDON.—Dr. J. H. Clapham, Litt.D., C.B.E., Lecturer in History and Economics, King's College, Cambridge, will deliver two Lectures on "Britain on the Eve of the Railway Age," at the London School of Economics and Political Science, Houghton-street, Aldwych, W.C. 2, on Thursdays, February 21 and 28, at 5 p.m.

AMERICAN AUTOMOBILE PRODUCTION.—The records for 1923 for the output of motor vehicles in the United States have exceeded all previous figures so far as they now are available. In the first eleven months of the year the output of cars and lorries was no less than 3,709,304 vehicles, and a total for the year was indicated at close on 4,000,000. For the whole of 1922 the previously best year, the total for all vehicles was 2,659,000.

4–6–2 LOCOMOTIVE CHART.—We received recently from the Locomotive Publishing Company, Limited, of 3, Amen-corner, Paternoster-row, E.C.4, an excellently produced half-tone diagram of one of Mr. H. N. Gresley's 4–6–2 three-cylinder express locomotives of which we gave an account in ENGINEERING in 1922 (vol. cxiii, p. 454). The diagram represents a longitudinal section of the engine, and the tinting and shading is very effectively done so that the parts stand out in a very realistic manner, which will be of assistance in visualising the internal parts to many who find a working drawing complicated and difficult to follow. The diagram is 30 in. in length; all the parts are numbered and a tabulated index list is given below. The publishers have produced a very excellent representation of the machine. Copies may be procured from them at the small cost of 1*s.* 6*d.* each.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—A substantial advance is shown in the official return relating to the past year. The total taken to Hull, 6,944,266 tons, was an increase of 1,546,000 tons as compared with 1922. Exports expanded greatly, the total being 4,377,856 tons, compared with 2,852,678 tons in 1922. Germany was by far the largest buyer, taking an aggregate tonnage of 1,755,537 tons. The next largest quantity was sent to Holland—785,914 tons. France took well over 500,000 tons, and other prominent buyers were Sweden and Belgium. Business with Russia revived to the extent of 135,438 tons. The premier place among contributing collieries was taken by the Brodsworth, Bullcroft, Hickleton, Ramcroft, and Yorkshire Main group, with over 1,000,000 tons, against 990,000 tons the previous year. The Denaby and Cadeby collieries occupied the second position with 612,122 tons, compared with 583,868 tons in 1922. For the month of December alone receipts showed a decline of 15,000 tons compared with the corresponding month of the previous year, the total being 460,177 tons.

Iron and Steel.—Reports from the leading engineering and steel works are mainly optimistic, though there is a certain amount of evidence that the unsettled political position, coupled with the threat of railway trouble, is having an adverse influence on the placing of new business. The actual volume of work in hand, however, shows a marked improvement, especially in those departments catering for railway and electrification requirements. Some of the smaller works supplying light castings, fittings, and constructional parts to automobile engineers are working at full capacity and have good prospects. Conditions have also brightened considerably at some of the tool works. Engineers' demands are in the ascendant, and business is opening out nicely in mining and quarrying tools and implements. Forges and foundries are slightly better off, but rolling mills could handle much more work; some of these are only operating alternate weeks.

South Yorkshire Coal Trade.—Continued pressure on house coal pits, coupled with the difficulty experienced in keeping up to date with deliveries owing to the wagon shortage, has resulted in further substantial advance in best grades, ranging from 1*s.* to 3*s.* per ton over the past fortnight. There is virtually nothing on offer for open market disposal, contracts absorbing the whole output. Best steams are firm with an upward tendency, though without any quotable change. Cobbles, nuts and slack continue in fair demand. Cokes unchanged. Quotations: Best handpicked branch, 35*s.* to 36*s.*; Barnsley best Silkstone, 30*s.* 6*d.* to 32*s.*; Derbyshire best brights, 30*s.* to 32*s.*; Derbyshire best house coal, 26*s.* to 27*s.*; Derbyshire best large nuts, 24*s.* 6*d.* to 25*s.* 6*d.*; Derbyshire best small nuts, 18*s.* 6*d.* to 20*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* to 22*s.* 6*d.*; rough slacks, 12*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 5*s.* to 8*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is a quieter feeling in Cleveland pig iron, keen Continental competition being felt in home and foreign markets. Export transactions are practically unheard of, and home sales show some shrinkage. There is still, however, a feeling that local and other home requirements will be such as to fully absorb output, and producers are very reluctant to lower prices. No. 1 is 102*s.*; No. 3 g.m.b., 99*s.*; No. 4 foundry, 97*s.*; and No. 4 forge, 96*s.*—all f.o.t. makers works, and f.o.b. Tees. One or two parcels of Continental iron are reported to have been unshipped here.

Hematite.—Little new is ascertainable concerning the hematite position. Some producers are well sold, and refuse to make price concessions, but others less fortunately placed are not disinclined to entertain offers at a shade below recognised market figures. In this branch also sales are almost entirely on home account. Nos. 1, 2 and 3 are quoted 102*s.* 6*d.* and No. 1 is put at 103*s.* 6*d.*

Blastfurnace Coke.—Values of Durham blastfurnace coke are falling, but are still a good deal too high to meet the views of local consumers. Good medium qualities are in the neighbourhood of 36*s.* delivered in this district.

Foreign Ore.—Sellers of imported ore are reluctant to acknowledge downward movement in prices, but buyers declare they can readily purchase on the basis of 24*s.* c.i.f. Tees for best rubio.

Ironstone Miners Wages.—Cleveland ironstone mine-owners, and miners representatives have agreed to a reduction of 5 per cent. in miners wages to take effect from the 28th inst.

Ironstone Mine Owners Association.—At the annual meeting of the Cleveland Ironstone Mine Owners Association at Middlesbrough this week, Sir Hugh Bell, Bart., was re-elected Chairman, and Sir A. F. Pease, Bart., and Mr. W. W. Storr, Vice-chairman.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel have good contracts secured but would welcome further orders, and hope that the fair number of inquiries still circulating will result in more work being booked. Common iron bars are 12*l.*; iron rivets, 14*l.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel

ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles and joints, 10*l.*; heavy steel rails, 9*l.* 10*s.*; and fish plates, 13*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The improvement which has been noticeable in general trade during recent weeks has failed to make much headway since the year commenced. The steel trade did quite a fair amount of booking towards the end of last year, chiefly through the re-commencement of work in the shipyards and the placing of many contracts by the railway companies. The net result of this was quite a satisfactory tonnage to begin with when the works were re-opened last week. Inquiries are fair and there are prospects of more orders being fixed up in the near future, but these will require to come along very soon if the regular running of the various works is to be ensured. One or two odd ship-building orders have again been reported, but buyers of steel in general do not seem to have much inclination to commit themselves to any extent in the meantime. The black sheet makers are doing fairly well at the moment and order books are well filled. Light and galvanised sheets are both moving freely, and while the heavier gauges are better than they were, there is still much room for improvement. Prices are keeping firm and the following are to-day's quotations:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; Sections, 10*l.* per ton; and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The West of Scotland malleable iron trade is moving very slowly this week. There was a fair amount of work to begin operations with, but the output capacity of the district is very large and no distance ahead can be seen. Bookings since the holidays have not been very heavy and managements are viewing the future with some anxiety. Inquiries generally are only fair, although we are promised a revival of trade before long. Prices are steady with "Crown" bars called 12*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—Little that is fresh falls to be recorded in connection with the Scottish pig-iron trade this week. Work is going along smoothly but little pressure is being made for deliveries and new contracts are not very plentiful as yet. Steel-makers are taking in fair lots of hematite against contract and the same may also be said about the consumers of foundry grades. Inquiries over all are quite good and there are prospects of some good lots being secured on export account. Prices for hematite iron are steady at 5*l.* 8*s.* 9*d.* per ton, delivered at the steel works, but foundry iron is the easier at 5*l.* 10*s.* per ton for No. 1, and 5*l.* 5*s.* per ton for No. 3, both on trucks at makers' yards.

Shipments of Scottish Pig-Iron.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, January 12, amounted to 654 tons. Of the total 555 tons went overseas and 99 tons coastwise. For the corresponding week last year the figures were 2,964 tons foreign, and 69 tons coastwise, making a total shipment of 3,033 tons.

Reduction in Price of Copper Tubes.—It was intimated in Glasgow yesterday that a reduction of ½*d.* per lb. had been made in the price of seamless and brazed copper tubes. The current prices is now 1*s.* 1*d.* per lb.

Clyde Shipbuilding Order.—Messrs. Napier and Miller, Old Kilpatrick, has just secured the contract to build a steamer of 5,500 tons deadweight carrying capacity for Messrs. George Nisbet and Company, Glasgow.

THE SYDNEY HARBOUR TRUST.—The report of the Harbour Trust Commissioners for Sydney shows that in the year ending June 30, 1923, the vessels entering the ports were 105 fewer than in the preceding year, but the tonnage represented an increase of 2,304,997. This is a striking indication of the increase in size of the vessels making use of the port. The total tonnage of vessels entering the port was 15,047,988 gross, and 8,813,432 net. The total tonnage was only 6 per cent. behind that of 1914, which was the port's highest record. The net revenue amounted to 852,242*l.*, and expenditure to 229,849*l.* The interest on capital debt was 514,756*l.*, and a surplus of 83,870*l.* remained after settlement of all payments. Capital works involved during the year an expenditure of 279,727, mostly spent in connection with new roadways, and a new wharf on Darling Harbour. The western entrance channel has been practically completed to 40 ft. at low spring tides to a width of 700 ft. The Eastern Channel will now be taken in hand.

THE STRUCTURAL ENGINEER.—This is the title of the official journal of The Institution of Structural Engineers. The first issue of the new volume has just been published under the editorship of Mr. H. Bryant Newbold, M.S.A. From the notes on society matters we learn that it is intended for found branches of the Institution in the Midlands, with Birmingham as a centre, and in Scotland, with headquarters at Glasgow and Edinburgh. There are already provincial branches for Lancashire and Cheshire, and for the Western Counties. Other matter includes a reprint of the paper on "The Practical Designing of Structural Steel Work Details," which was read before the Institution last December by Mr. J. B. Clarke. Other papers published deal with the "Timbers of the Empire," describing the investigations of the Timber Committee of the Imperial Institute and the "Algebra of Magnitudes." For the paper first named Mr. H. D. Searles Wood, F.R.I.B.A., is responsible, whilst Mr. E. F. Etchells is the author of the last named, which is the first of a series which is to be continued.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Exports of coal from the principal Welsh ports in 1923 amounted to 29,487,574 tons compared with 25,197,637 tons in 1922. The value of last year's shipments was 38,534,544*l.* against 30,666,081*l.* in 1922 and the average realised f.o.b. price per ton 26*s.* 2*d.* compared with 24*s.* 4*d.*, an increase of 1*s.* 10*d.* per ton. In December there were only 23 working days, because of the intervention of the Christmas holidays, and shipments amounted to 2,203,478*l.* tons valued at 2,789,243*l.* or 184,172 tons less than in November. The December quantity was the smallest for the year while the revenue derived was only less in February. The average price secured for the December shipments at 25*s.* 4*d.* was 2*d.* per ton less than that obtained in November. All the ports, with the exception of Newport, shared in the reduction, Cardiff recording a decrease of 130,690 tons, Port Talbot of 42,639 tons and Swansea of 46,666 tons but Newport registered a gain of 35,823 tons. The average price of coal shipped from Cardiff and Newport was higher by 1*d.* but at Port Talbot and Swansea, respectively, was 1*s.* and 1*s.* 8*d.* per ton lower. The volume value and average f.o.b. prices for the different ports in December were as follows:—

From	Tons	Value in £	Per Ton.
Cardiff ...	1,340,224	1,692,141	25*s.* 3*d.*
Newport ...	438,724	561,889	25*s.* 7*d.*
Port Talbot	180,278	209,051	23*s.* 2*d.*
Swansea ...	244,252	326,162	25*s.* 4*d.*

Exports of large coal in December amounted to 1,435,807 tons, valued at 2,015,409*l.*, or 28*s.* 1*d.* per ton which was 6*d.* less than in November, while small coal amounted to 697,105 tons valued at 694,339*l.*, or 19*s.* 11*d.* per ton a reduction of 1*d.*, while through coal shipments totalled, 70,564 tons valued at 79,445*l.*, or 22*s.* 6*d.* per ton, an increase of 1*s.* 1*d.* per ton. No settlement has been reached in connection with the continuation of third shift working at the South Wales ports. The Court of Inquiry resumed its sittings as a conciliation committee yesterday but failed to come to any agreement. A formal recommendation is, however, expected at an early date. The possibility of a settlement is, however, remote and there is every probability that night working will be suspended at all the Welsh ports at the end of the week, the trimmers and tippers at Newport, Swansea and Port Talbot having decided to fall in line with those at Cardiff, Penarth and Barry. The miners have decided by a large majority to terminate the present agreement at the end of March.

Iron and Steel.—Exports last week totalled 26,850 tons compared with 23,431 tons in the previous week. Shipments of tinplates and terneplates amounted to 12,304 compared with 11,956 tons, blackplates and sheets to 6,611 against 6,728 tons, galvanised sheets to 4,230 tons against 1,925 tons and other iron and steel goods to 1,363 tons against 2,822 tons.

SWEDISH PORTS.—A booklet in English, published by the A.-B. Gunnar Tisells Tekniska Förlag, Stockholm, gives illustrated information on 51 Swedish ports and customs towns, the particulars including an historical review, the development of the ports and cities, the facilities they offer to shipping and trade, and recent statistics. The work also reviews the railways, the inland waterways, customs system, and shipping dues of the country. It gives evidence of having been prepared with great care, and should prove useful to a large number of British and American shipping lines.

NEW DANISH AGRICULTURAL EXPORT STEAMER.—On October 10 a new steamer, the *Hroar*, built at the Frederikshavn wharf for the United Steamship Company, Copenhagen, for its agricultural expert service between Copenhagen and Hull, left on its first trip, reports the Danish Foreign Office Journal. The new steamer is of the most modern construction, 1,400 tons gross, speed 14·5 knots, and with a cargo capacity of 96,225 cub. ft., of which 56,300 ft. are isolated and equipped with refrigerating machinery. The boat has also accommodation for 24 first-class and 12 third-class passengers. When formally taking over the new steamer from the wharf, the Chairman of the United Steamship Company stated that they also had under construction four similar modern boats, while three others had already been reconstructed, the idea being that the company's boats on the English service should always be able to travel with full cargoes of agricultural produce. In the past eight months the export to England from Esbjerg alone reached 113,000 tons.

THE SPANISH NAVAL PROGRAMME.—The visit of the King of Spain to Italy during the last quarter has aroused a good deal of interest and discussion in Spanish naval circles. At the present moment the following ships are in hand; practically all the work is being done by the Sociedad Espanola de Construccion Naval, which employs 1,200 permanent hands and officials and about 10,000 casual artisans. Two light cruisers of 7,850 tons and 33 knots, armed with eight 6-in. guns and 12 21-in. torpedo tubes. Three flotilla leaders of 1,650 tons and 36 knots, armed with five 4·7-inch guns and six triple 21-in. torpedo tubes. Three destroyers of 1,300 tons and 34 knots armed with three 4-in. guns and two twin 21-in. torpedo tubes. Three gunboats of 1,335 tons and 15 knots, armed with four 4-in. guns. Two submarines of the "B" type, 600 tons on the surface and 740 submerged, and six of the "C" class 900, tons on the surface and 1,290 submerged.

NOTICES OF MEETINGS.

THE INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Friday, January 18, at 7.15 p.m. in the Metallurgical Department, University College, Singleton Park. Paper on "Annealing of Non-Ferrous Metals," by Captain L. Taverner, A.R.S.M.

UNIVERSITY COLLEGE OF SOUTHAMPTON ENGINEERING SOCIETY.—Friday, January 18, at 7.30 p.m., at the University College, Southampton. Paper on "Wireless Telephony," by Mr. John Smith.

ROYAL SOCIETY OF ARTS; INDIAN SECTION. Friday, January 18, at 4.30 p.m. "The Survey of India," by Colonel H. L. Crosthwait, C.I.E., R.E., retired, late Superintendent Survey of India.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, January 18, at Bolbec Hall, Newcastle-on-Tyne. "Influence of Propelling Machinery on the Running Costs of Ships," by Mr. W. G. A. Perring.

THE INSTITUTION OF ENGINEERING INSPECTION.—Friday, January 18, at 8 p.m., at the Royal Society of Arts, John Street, Adelphi, W.C.2. Lecture: "Reminiscences of Railway Work Overseas," by Mr. Frank Groves, O.B.E., M.Inst.C.E.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 18, at 7 p.m. Informal Meeting. Subject for discussion: "British Locomotive Practice and Performance" introduced by Mr. R. E. L. Maunsell, C.B.E., on November 23, 1923, Sir Henry Fowler, K.B.E., in the Chair. Friday, January 25, at 6 p.m., General Meeting. Lecture by Major G. Le Q. Martle, D.S.O., M.C., R.E., on the "Progress of Mechanical Engineering in the Military Services." Graduates' Section, London, Monday, January 21, at 7 p.m.: "Recent Improvements in Locomotive Efficiency," by Mr. E. L. Diamond, Student; Chairman, Mr. R. E. L. Maunsell, C.B.E., Member of Council.

BRADFORD ENGINEERING SOCIETY.—Monday, January 21, meeting in the hall of the Bradford Technical College, at 7.30 p.m. Mr. H. Cecil Booth, M.Inst.C.E., on "Suction Plant for cleaning Boiler Flues."

ROYAL SOCIETY OF ARTS.—Monday, January 21, at 8 p.m: Cantour Lecture, "Colloid Chemistry," by Eric Keightley Rideal, M.B.E., M.A., Ph.D., D.Sc., F.I.C. (Lecture I.) Wednesday, January 23, at 8 p.m.: Ordinary meeting, "Cinematography in Natural Colours—further developments" (with illustrations—scenes from H.R.H. the Prince of Wales's Tour in India), by G. Albert Smith. George E. Brown, editor of the "British Journal of Photography," will preside.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 22, at 6 p.m. Papers to be submitted for discussion: "The Effect of Shape of Catchment on Flood-Discharge," by Colonel Gordon Risley Hearn, D.S.O., R.E., Assoc.Inst.C.E.; "Discharge from Catchment-Areas in India, as Affecting the Waterways of Bridges," by Mr. George Ernest Lillie, F.C.H., M.Inst.C.E.; "Floods of the Damodar River, and Rainstorms producing Them," by Mr. Ernest Leslie Glass. Students' Meeting, Wednesday, January 23, at 6 p.m.: Lecture on "The Work of a Mechanical Engineer's Office," by Mr. Alfred John Hill, C.B.E., M.Inst.C.E. Students' Visit, Wednesday (afternoon), January 30, to the Chiswick Research Laboratory of the Still Engine Company, Limited.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, January 22, at the Royal Society of Arts, John Street, Adelphi, London, at 8 p.m., when a Discussion on "Co-ordination of Research in Illuminating Engineering and Some Practical Applications" will be opened by Mr. J. S. Dow.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, January 23, at 8 p.m., at the Society's Rooms, The Temple, Dale Street. Paper on "Lubrication," by Mr. R. Ablett, M.Sc.

THE INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, January 24, at 8 p.m., at Denison House, 296, Vauxhall Bridge Road. Major James Petrie, O.B.E., M.I.Struct.E., will deliver his Presidential Address.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Thursday, January 24, at 6.30 p.m., at the Institution of Mechanical Engineers, Storey Gate, St. James Park, S.W.1. Informal Meeting. Demonstration of Testing Instruments.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, January 25. at 9 p.m., a discourse will be delivered by Sir Aston Webb, K.C.V.O., C.B., on "The Future Development of London."

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 25, at 39, Victoria-street, at 7.30 p.m. Special Meeting: Lecture, "Molecular attraction and its Relation to Engineering," by Professor Edwin Edser (special projections).

THE HULL ASSOCIATION OF ENGINEERS.—Saturday, January 26, at 7.15 p.m., in the Municipal Technical College, Park Street. Lecture on "Steam Boilers," by Mr. H. E. Pearsall.

CONTRACTS.—Messrs. Vickers, Limited, Hydro-Electric Department, have received an order for a 25,000 h.p. water turbine, which they will instal at Calumet Island, on the Ottawa River in Canada. The river falls 60 ft. at this point, and a power station is now under construction which will eventually house three units such as the above. This is in all respects the largest single-runner Francis water turbine which has been built in England.

"RAPID" SCREWING MACHINE.

CONSTRUCTED BY MESSRS. SCOTT BROTHERS (KEIGHLEY), ENGINEERS, KEIGHLEY.

(*For Description, see Page* 77.)

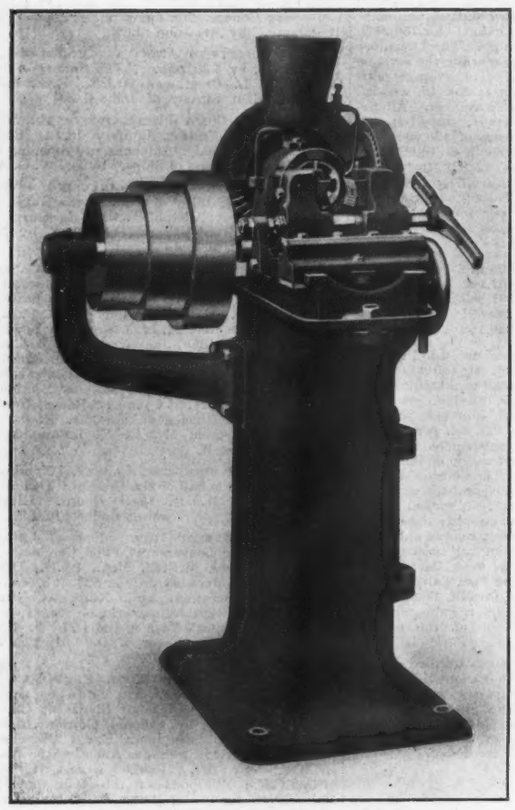


FIG. 1.

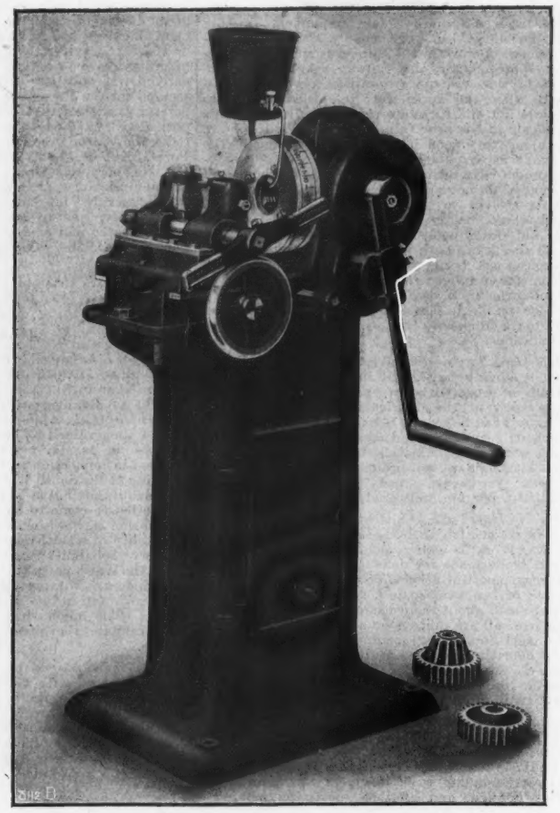
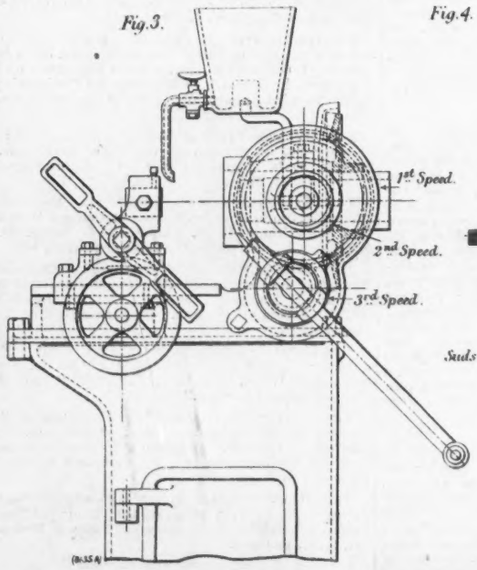
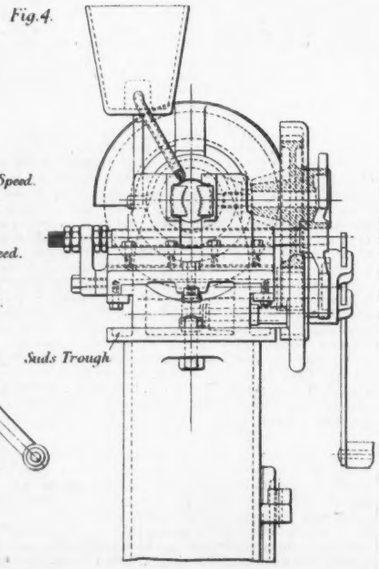
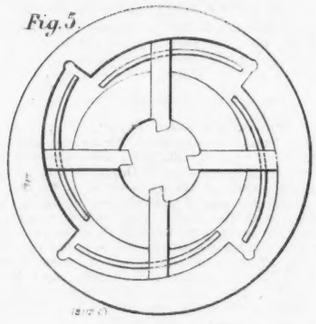
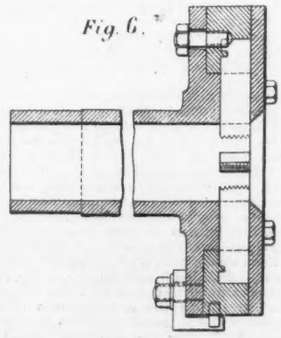


FIG. 2.









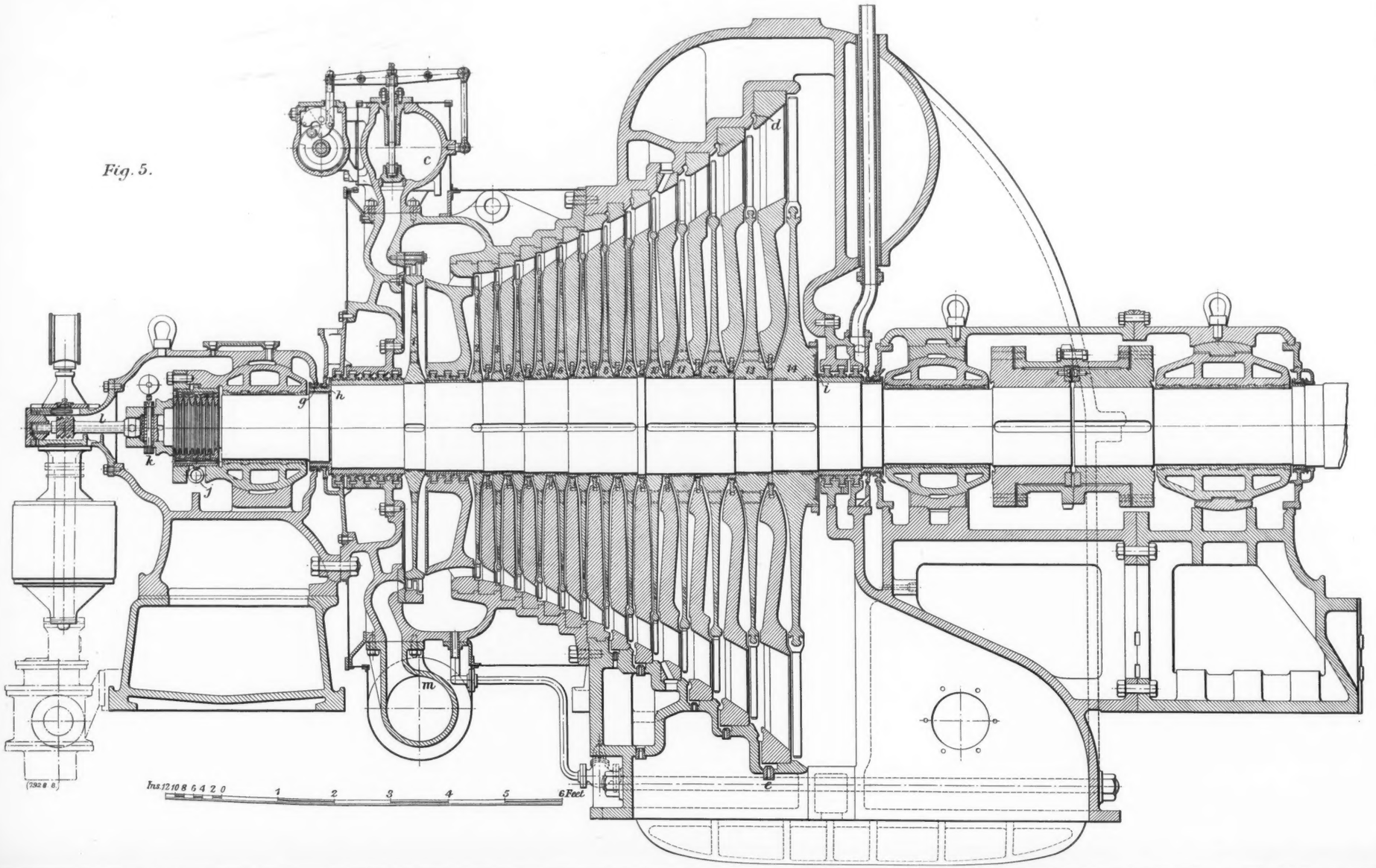
ITALY ON THE SEA.—The Fascista Government has organised a new initiative, according to a report of the British Chamber of Commerce for Italy. A large ship, the Italia, is being sent for a cruise in South American waters, fitted out with specimens of all Italy's latest achievements in industry, art, literature, and science. The primary object of the voyage is to acquaint the large colonies of Italian settlers in South America with what is being done in Italy, and to bring them into visible contact with the motherland. Since Mussolini came to power he has persistently tried to raise the position of Italian emigrants and to make them feel that they are still part of Italy, and necessary to her welfare as she is necessary to theirs. The Italia has seventeen showrooms, each containing exhibits of some special Italian industry, such as marble, textile fabrics, electrical works, books, motor-cars, aeroplanes, &c., There are separate exhibitions of the most characteristic agricultural products of the different Italian regions. The cruise, which is to last seven months, will cover 23,000 miles. The Italia will touch at thirty South American ports.

30,000-KW. STEAM TURBO-GENERATOR FOR THE ROTHERHAM CORPORATION.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 65.)

Fig. 5.



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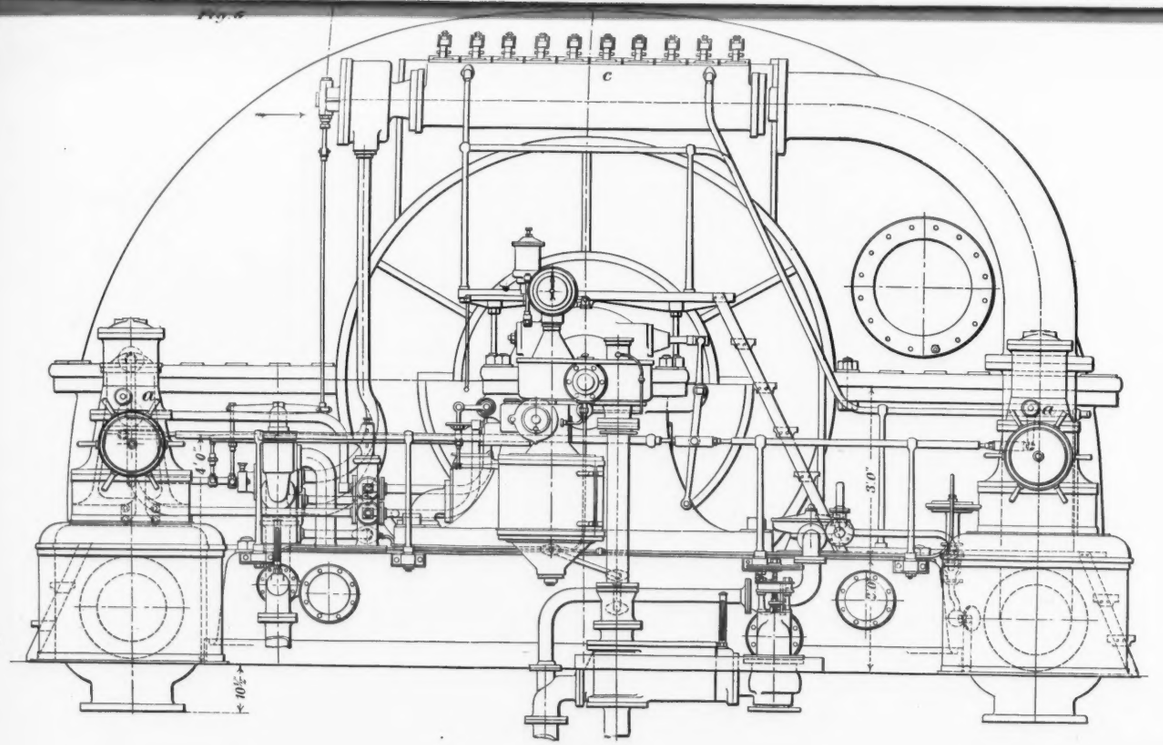

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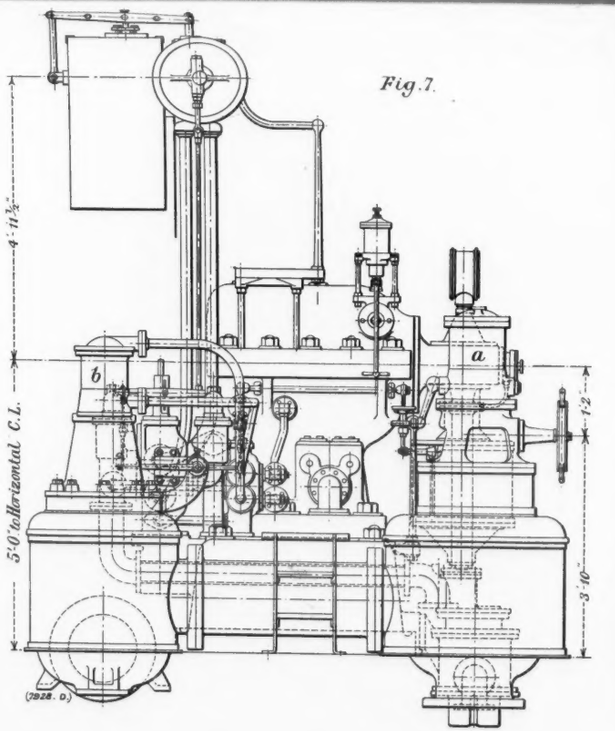

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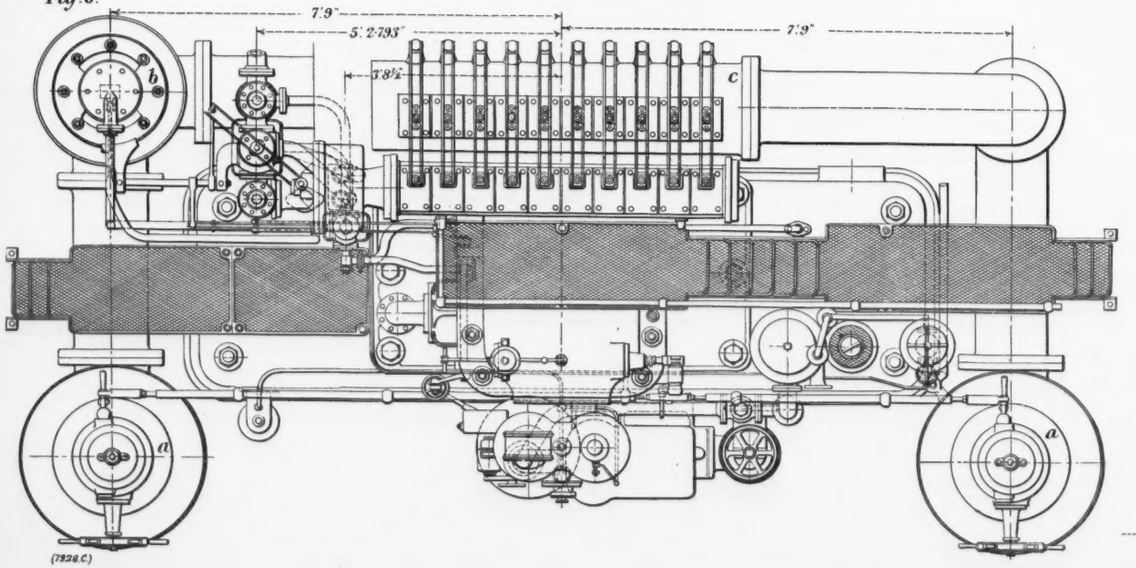

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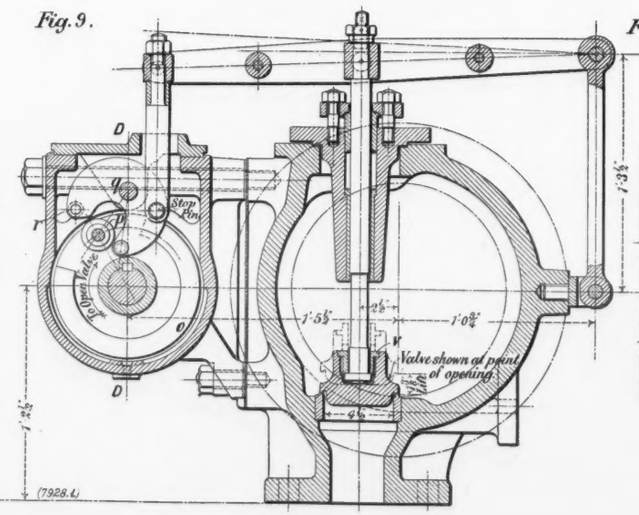

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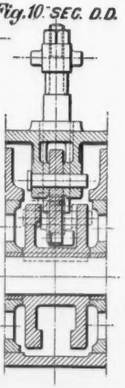

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ENGINEERING.

FRIDAY, JANUARY 18, 1924.

THE BRITISH EMPIRE EXHIBITION.

THE British Empire embraces a quarter of the known globe and has a population of 450 millions. The countries within its confines represent every climate and contain a family of peoples of almost every faith and every colour. This amazing organisation is but loosely held together, but the lack of rigidity in its connecting links enables it to adjust itself to new conditions or new difficulties as they may arise. This loosely knit structure faced and came through the Great War in a way worthy of the history of the race which founded it. The genius, or the common sense, or whatever one may call it, of that race is not, however, displayed only in war, and its behaviour since the end of 1918 has set an example which might with profit have been more generally copied. In the art of war we have little to learn, but it has more than once been suggested that in the arts of peace we might usefully study some of the proceedings of others, and particularly their superior ability in letting outsiders know something of their activity and qualifications. There is something in this. Reticence is an admirable quality, but in the modern era of crowded populations and world-wide trading it is necessary that proper opportunity should be given to outsiders to know more, both of the material resources and the capabilities of the British Empire. A valuable common effort in this direction is to be made at Wembley this year, where the British Empire Exhibition opens early in April. This exhibition will represent an effort worthy of the Empire of which it will stand as a microcosm.

The Exhibition will show to the world, and perhaps for the first time to many of ourselves, the wealth of natural products and manufactures which the British Empire is able to put at the service of mankind. To display adequately the products of the Home Country and of the Dominions, Colonies, and Overseas Dependencies demands a material effort of great magnitude, but that effort has not been lacking and every Empire member has contributed willingly and freely to the very remarkable organisation which is now growing up. Wembley will be remembered as one of the great exhibitions of modern times and will have a place in the memory of the future akin to that occupied by the great achievement in Hyde Park in 1851 in the memory of the latter half of the nineteenth century. The 1851 Exhibition did much to foster and extend British industry and trade, and industry and trade are, and must be, the very basis of our existence. It may be both hoped and expected that Wembley will do the same things even in greater measure for a newer generation.

The total area of buildings at the 1851 Exhibition was 25 acres, and perhaps no better illustration of the position to which engineering and its allied industries have grown since that time could be given than is conveyed by the fact that this area will be equalled by the Palaces of Engineering and Industry alone at Wembley. The engineering building is about six and a-half times the area of Trafalgar Square and is probably the largest ferro-concrete building in the world. It is twice the size of the machinery hall of the Franco-British Exhibition of 1908. These great buildings have not been put up merely with the idea of surpassing what has been done before, but because they are necessary to contain the huge quantity of machinery and other material which will be on view. The Palaces of Engineering and Industry represent only the contribution of the manufacturers of this country, and great buildings for their own products are being erected by Canada, Australia, India, South Africa, and the other Empire countries. The engineering display, in which we are naturally specially interested will be of a remarkably complete character. The mechanical engineering section, which is being organised by the British Engineering Association, will contain the display of some 300 engineering and shipbuilding firms, some of which propose to display their products on a very lavish scale. Individual firms are, we believe, spending as much as 50,000*l.* on their stands. The electrical section, organised by the British Electrical and Allied Manufactures Association, will contain displays by practically every electrical firm in the country. Some 150 have now been arranged for, and 98 per cent. of the available space is let. The motor and cycle section, organised by the Society of Motor Manufacturers and Traders and the British Cycle and Motor Cycle Manufacturers and Traders Union, will contain displays of some 200 firms, while the land and sea transport section will contain exhibits by all leading railway companies, shipping companies, and builders of rolling-stock.

The lowest estimate of the total number of visitors to the exhibition is placed at 25 millions. This figure should easily be passed. To the Paris Exhibition of 1889 32 million visits were paid; while to that of 1900 the figure was 39 millions. Our Hyde Park Exhibition of 1851 drew 6 million visitors, and the Vienna Exhibition of 1873 some 7 millions. The mechanical section of this Vienna show formed a landmark in engineering displays, very much important engineering material being shown at it for the first time. It is to-day of special interest to us, and we dealt with its engineering features in very great detail in our columns, and it formed the starting point of our traditional policy in dealing with important engineering exhibitions. We will hope to display the same care and thoroughness in connection with the important engineering display at Wembley in due course.

As we have mentioned, it is estimated by the organisers that at least 25 million people will visit the Exhibition, and the figure naturally raises interesting speculations about transport. The figure must be doubled to give the total number of passenger journeys for which facilities must be provided, which, on the average, works out at, say, 300,000 journeys for each day during which the Exhibition will be open. The figure of 25 millions is easily surpassed by the 32 and 39 millions which we have quoted for the Paris Exhibitions, but these shows were held not very far from the centre of the city and the transport problem was of a very different order from that presented by Wembley,

which is 7 miles from Piccadilly Circus. A better parallel is furnished by the Chicago Exhibition of 1893, which was situated some 7 miles out of the town. The total number of visitors to the Exhibition was 21 millions, and it is stated that 700,000 visitors attended it on one day. This would represent 1,400,000 journeys against the 300,000 required by our figure for Wembley. This figure is, however, the average for the whole period of opening and must be greatly exceeded on certain days, so that one may expect the Chicago figure to be approached. The Chicago Exhibition was situated on the side of Lake Michigan and an important proportion of the total number of visitors were conveyed by steamer. In addition, transport was available by cable tramway, elevated railway and on six tracks of the Illinois Central Railroad. Wembley has nothing corresponding to the lake service, but is being held at a time when road transport has advanced far beyond the stage it occupied in 1893. The Exhibition is also able to take advantage of the possibilities of modern electric traction as it is served by the Metropolitan Railway at Wembley Park Station and the electrified Watford line at Wembley Station. Sudbury Station, served by the District Railway, is also only ten minutes away from one of the entrance gates. Steam railway facilities from Marylebone are available to Wembley Hill Station and to a special station which has been constructed inside the Exhibition grounds. These various facilities, combined with the experience in handling suburban traffic which is available in London, make it certain that the facilities will prove sufficient even if the figures of the record Chicago day are approached.

The construction of the Exhibition buildings is well forward and the important Palaces of Engineering and Industry were handed over by the contractors, Messrs. Sir Robert McAlpine and Son, in November. The heavy exhibits are now being put in place and the power station is being erected. This station adjoins the engineering building and will supply current to the Exhibition generally, both for lighting and power. An alternative and stand-by supply will be available from the mains of the North Metropolitan Electric Supply Company. The station, which will be equipped with two water-tube boilers manufactured by Messrs. Babcock and Wilcox and two manufactured by Messrs. John Thompson, and three 1,500 kw. turbo-generators supplied by the British Thomson-Houston Company, the English Electric Company, and the General Electric Company, will generate 3,300-volt 3-phase current, which will be stepped down or transformed in three sub-stations to either 415-volt 3-phase, or 220-volt and 440-volt direct current. Certain large motors driving machinery will be supplied direct at 3,300 volts. We understand that some 10,000 kw. of power has already been applied for, so that the alternative supply from the North Metropolitan Company will be called upon to a very large extent. In addition to the plants we have mentioned, some smaller units will be situated in the engineering building close alongside the power station, and will feed into the same cable networks. They will be driven by a Paxman-Lenz steam engine, a Blackstone horizontal oil engine, a Ruston and Hornsby vertical cold-starting oil engine, and a Garrett semi-stationary set. This somewhat miscellaneous collection of prime movers make up a plant which hardly has the unity one looks for in a modern power station, but is, of course, being installed in order to illustrate the range of generating plant covered by British manufacturers. As all necessary transformers and control gear will, of course, be installed the mere power installation of the Exhibition will in itself form a valuable display of modern engineering material.

THE SUBMARINE DISASTER.

ON Thursday, the 10th inst., the Secretary of the Admiralty communicated to the press a statement announcing the sinking of submarine "L. 24" whilst exercising off Portland and the feared loss of her officers and crew, which subsequent statements showed were 43 in number. The approximate position at which she sank was known and efforts were being made to locate the wreck. Later press messages stated that the dredging operations had resulted in the location of what was believed to be the wreck, but that until the weather had moderated it was impossible to confirm that it was that of the submarine. Later, it was announced that divers had examined the wreck but were not certain it was that of "L. 24." Its position is 11 miles from Portland Bill and in a direction west by south-west, the depth being 30 fathoms. It is also stated that whilst at exercises with the Fleet "L. 24" was rammed by the battleship Resolution, and that divers who had examined the bottom plating of the battleship had found evidence confirmatory of this, although it is reported the ship's officers had experienced no perceptible shock of collision at any time. A Court of Inquiry is sitting at Portland examining all available evidence, and there is little doubt the Secretary of the Admiralty will communicate the results as soon as they are determined.

According to the published particulars of British war vessels, "L. 24" was built and engined by Messrs. Vickers of Barrow and was one of a large class—about 30—constructed during the war. The earlier vessels of the class appear to be slightly shorter than "L. 24," whose length was 238½ ft., beam 23½ ft., and surface draught 13½ ft. The surface displacement was 890 tons and submerged 1,080, the difference, 190 tons, representing approximately the contents of the ballast tanks, which are empty when on the surface and filled when the vessel submerges. The engines were of 2,400 h.p. and the electric motors of 1,600 h.p., giving speeds on the surface and submerged of 17½ and 10½ knots respectively. The amount of oil fuel carried was 76 tons, and although the radius of action is not stated this quantity of fuel should render it a fairly large one, sufficient for work in the North Sea and around the British Isles, a service which such vessels were primarily intended for. The armament of "L. 24" is given as four torpedo tubes and 14 mines, whilst others of the class carry six torpedo tubes and one 4-in. gun.

The first of the "L" class—the type is generally termed patrol submarines—was launched in May, 1917, and completed in November of the same year. Several were in service before the Armistice, and, it is generally understood, performed good work during the period of the war in which they were in commission. They are generally similar in design and construction to the "E" class in commission at the outbreak of war, which were largely augmented in numbers during hostilities, but which have now disappeared. The "E" class were of about 700 tons surface displacement and 15 knots surface speed, the greater size of the "L" class being necessary for their higher speeds and more powerful armament. The "L" class, therefore, developed along well tried lines, and so far as can be judged generally, have nothing very novel in comparison with previous successful types. "L 24" was launched in February, 1919, and completed 12 months later. She would thus embody all those features which three years' experience with her earlier completed sisters had shown to be advantageous for their submerged navigation and general efficiency, and which in such complicated masses of mechanism as the moden submarine, cannot wholly be foreseen in the design stage.

Early types of submarines were not divided internally by main watertight transverse bulkheads, but modern types are so divided, the spacing of the bulkheads being as close as practicable and as convenient for the installation of the machinery motors, batteries, &c. This subdivision is intended primarily as a protection against sinking from damages resulting from collision on the surface. The reserve of buoyancy of a submarine when on the surface is from 10 to 20 per cent. of the surface displacement, and if when damaged by collision or otherwise the amount of water can be restricted to less than the reserve of buoyancy she will remain afloat. In earlier classes without bulkheads the whole of the interior was flooded if the pressure hull were pierced and the vessel sank. In modern types the bulkheads restrict the damage and the vessel will generally remain afloat. When, however, a submarine is navigating submerged there is no reserve of buoyancy, and any appreciable addition to the weight will cause her to sink. Small additions can be dealt with by the hydroplanes or by the pumps. If a submerged submarine is damaged by ramming and a hole in her pressure hull results, water will enter quickly and she will sink to the bottom. If the depth of water is small and the pressure less than that to which the bulkheads are tested, the bulkheads will restrict the water to the damaged compartment and the crew may find refuge in other spaces. This happened in "K 13," which sank in the Garloch in 50 or 60 ft., the majority of those on board being rescued. If, however, the depth is great, the pressure on the bulkheads being more than they are capable of withstanding will cause them to collapse and the whole interior will be flooded. It is not known to what pressure the bulkheads of "L 24" were tested but it would hardly be that corresponding to a depth of 180 ft. or about 80 lb. per square inch.

Earlier types of these craft were not fitted with means of communication with surface ships, if from any cause they sank and were not by their own efforts able to rise to the surface. Modern submarines have been fitted with telephone buoys, which are freed from the vessel in case of necessity and which permit them to converse with those on the surface. As a result of developments during the war, other means of communication are now available, in case there are survivors in the wreck. It would appear from newspaper accounts that in the present instance, although a prolonged, anxious and attentive watch has been maintained by surface craft in the locality of the wreck of "L 24," no signal or sound of any sort has been detected.

It is only on such melancholy occasions as the present that the general public becomes aware of the intensive training which all ranks of the British Navy so cheerfully undergo in times of peace in preparation for the sterner struggle of war. It is also only at such a time that the dangers which attend the navigation and operation of submarines are dimly appreciated. With such enlightenment the deepest and sincerest sympathy will be forthcoming from all classes of the community to those whose relatives and friends have been lost to them whilst faithfully performing their arduous and dangerous duties.

PETROL LOSSES IN BULK STORAGE.

IN an article on "Evaporation Losses in the Petroleum Industry" in these columns some while ago,* attention was directed to the protection of the oil from evaporation during the processes to which it is subjected between the well mouth and the storage of the refined products. In connection with the latter great losses are suffered by petrol or gasoline, as these are the lighter and most easily vaporised. The effective protection of these from loss, therefore, becomes important, especially as the supply of petrol accumulates during portions of the year. Consumption, we believe, exceeds the supply in summer, but in the winter the reverse is true, and a good deal of this fuel goes into storage for use some months later on the return of better climatic conditions. In the United States at the end of April, 1923, the stocks of petrol on hand at refineries amounted to 1,336,418,000 gallons. As may be imagined, the total losses on stocks of this scale are very considerable, even if they are individually small, and much attention has lately been devoted to determining their actual values with a view to introducing preventive measures. It has been found that in general handling the greatest losses, as regards petrol, occur in connection with the filling and emptying of the storage tanks, while next in extent are those which arise from the "breathing" of the tanks under changes of temperature and other climatic conditions. With a view to improve the state of affairs various modifications have been introduced in tank construction, some of which are worthy of notice. It may be mentioned that when evaporation losses occur the actual loss in quantity is not so serious as the loss of the fractions themselves, which, in order to bring the petrol back to the selling specification have to be replaced at a considerable expense and trouble. The elimination of loss of this kind has effect in two directions. The factors which affect

* "ENGINEERING," Vol. cxiv, page 806.

the evaporation of stored petrol are the renewal of the air in contact with the liquid, the temperature of the surface of the liquid, the area of the evaporating surface, and the quantity of vapour in the air in contact with the surface. The work carried out has been directed towards preventing the renewal of the air over the surface, the maintenance of the liquid and air at suitable temperatures, and the reduction of the exposed liquid surface.

It is perhaps not realised outside the industry, and, in fact, has not long been realised within it, how "breathing" under ordinary climatic conditions may result in considerable loss. In a recent report on this subject issued by the Bureau of Mines, of Washington, the case is taken of a 55,000-barrel tank, 30 ft. high, and filled to 29 ft. The air space remaining in such a tank is 34,330 cubic feet, and if the temperature of this were raised 40 deg. F., some 2,800 cubic feet of gasoline-saturated vapour would be expelled. If the tank were only half full, under the same change of conditions, no less than 14,500 cubic feet of vapour would be expelled. The air thus driven out often contains 80 per cent. of petrol vapour, and the loss is thus heavy. Under summer conditions a range of 70 deg. F. may occur in 24 hours, when the breathing loss for a tank filled to 29 ft. would be about 3,700 cubic feet, equivalent to something like 97 gallons of petrol. These figures are taken for vapour-tight tanks furnished with relief valves.

The prevention of these losses has been attempted by several methods. In some cases water-cooling insulation has been adopted, while in others the attempt has been made, not to regulate the temperature of the air in contact with the liquid, but to prevent such contact. The value of such methods has lately been the subject of tests carried out by the Bureau of Mines, and some of the quantitative results are interesting.

In one test a non-cooled tank of the ordinary type was compared with a similar tank fitted with a water spray playing on the roof, and with a third tank the roof of which was arranged as a trough filled with water. The tanks were only of 250-barrel capacity and the petrol was 59·5 deg. gravity (A.P.I.). Without entering into details of the measurements taken, it may be stated that it was found that the loss in 85 days was only 0·65 per cent. for the spray-cooled tank, 0·9 per cent. for the water-trough roof, and 1·54 per cent. for the non-cooled tank. The loss in specific gravity was in the case of the spray-cooled tank only one-third what it was in the case of the non-cooled tank. This was confirmed by distillation records which at the beginning of the tests showed the petrol to give an initial point of 112 deg. F., this figure rising to 126 deg. F. for the spray-cooled tank after the test and to 133 deg. F. for the non-cooled tank—showing that in this latter more of the lighter fractions had disappeared. Temperature tests indicated that the average liquid temperature in the spray-cooled tank was 19 deg. F. below that of the non-cooled tank and 7 deg. F. below that of the roof trough-cooled tank. The average daily variation was also much less for the two water-cooled tanks, typical figures being 9 deg. F. for the roof trough-cooled tank and 17 deg. F. for the spray system, compared with 46 deg. F. for the non-cooled. The average vapour temperature was consistently lowest for the spray-cooled tank.

The cost of the spray would vary with the district, but used in the hot summer months might be expected to reduce the evaporation losses by one-half. Insulation alone, which has been tried in some cases, is not effective. If in filling, the liquid is pumped in hot, insulation will tend to maintain it at a high temperature, though the range of temperature may be reduced. In other systems the insulation is separated from the tank by an air space, and cold night air circulated in this, the dampers being closed during the day time. The most satisfactory means of preventing evaporation is reported to be insulation by means of a housing enclosing the tank, combined with a water spray on the tank roof, with a system of ventilation. The insulating housing, constructed of asbestos sheeting, is a good deal larger than the tank, and in the centre of the roof is provided with a 4 ft. cowl ventilator. At the ground level air openings are provided. The spray is arranged inside the insulating roof, playing on to the tank roof. The water runs down the tank sides and is cooled by the current of air passing up from the ground openings to the cowl. Tanks of this kind have shown only 19·3 deg. F. variation in vapour temperature, against 47 deg. F. for spray-cooled tanks without insulation. In the latter a wind may materially affect the efficiency of the spray.

The means adopted for excluding air from contact with the liquid stored include some ingenious form of floating roofs. In these cases the tank is cylindrical, but the roof, instead of forming part of the fixed structure, consists of a shallow pan or trough capable of floating on the surface of the liquid and rising and falling with it. To make this possible the circular trough has to be an easy fit within the cylindrical wall of the tank, and the manner in which the seal is made between the roof and the side of the tank is worked out in several ways. Owing to lap joints, rivet heads, &c., the seal has to adapt itself to irregularities, but a perfect seal is not attempted in many of the designs.

The liquid surface exposed to air in such a case is merely the annulus between the sides of the pan-roof and the tank walls, and the space under the seal covering this will be as small possibly as 180 cubic feet in a 55,000-barrel tank, thus affording much less chance for evaporation. The seal is effected by a series of deep shoes which slide up and down with the roof and are kept pressed by springs against the tank sides. In one case these shoes have horizontal limbs which rest on rollers arranged on the floating roof, and a small trough filled with oil is provided as a seal on the edge nearest the centre, an angle attached to the horizontal member dipping below the surface. In another case the shoes are suspended from curved arms attached to the roof and are pressed outwards by springs. In the latter case the seal is made by flexible jointing material between the several shoes and also between the shoes and the pan-roof. The interesting feature is that no vapour-tight seal is attempted in either of these designs between the shoes and the tank walls. The shoes have a length (in a horizontal direction) of about 4 ft. and are about 23 in. deep. They are liable to be pressed away from the tank sides by projecting heads, but the slit thus formed is so narrow that the vapour loss is very small indeed. Thus, in a tank 30 ft. in diameter, if the roof shoes allowed $\frac{1}{4}$ in. clear all round, only about 2 sq. ft. of surface would be exposed, while the depth and narrowness of the actual space would prevent anything in the nature of rapid air circulation. Under such conditions laboratory tests have shown evaporation to be extremely small. The saving effected by this type of roof compared with the ordinary canopy roof, amounted in some pumping tests to 1·3 barrels per 1,000 barrels pumped in cold weather; this amount would probably be doubled in hot weather.

The adoption of the type of seal last described enabled an interesting fire test to be carried out with a tank so fitted. In this test a lighted taper was first of all inserted between the shoes and the wall. A flash occurred and travelled round the tank, but at once went out as the supply of air getting down to the exposed petrol was insufficient to support combustion. Other tests followed with fires deliberately started on the roof. In most cases these soon burnt out without harmful effect or loss, while in the only serious case of a very severe test the fire was quickly brought under control by one man with four 2½-gallon extinguishers. In this case a fire was started by pouring 5 gallons of petrol on the roof. This burned for 15 minutes, sending up flames 8 ft. high round the edge and exposed petrol became ignited. Soon after the petrol on the roof was burnt out it was possible to cool the roof so that the flame around the shoe was extinguished. The deep, narrow space remaining round the tank wall does not present any serious danger in this type of roof.

ROAD AND STREET MAINTENANCE IN SCOTLAND.

AT the Scottish Road Conference, held in Edinburgh on Tuesday and Wednesday last, several interesting papers were read, falling roughly into two divisions. One of these dealt with the financial side of road problems; the other was concerned with maintenance and costs of upkeep. The conference gave an opportunity for bringing together a varied range of experience, and the three contributions we propose in the main to deal with were concerned respectively with the streets of Edinburgh and Glasgow and with roads in a typical county district.

In considering these questions account should, of course, be taken of the climatology of the country, which render some systems of proved service elsewhere inapplicable in Scotland. The rainfall is heavier (49 in. p.a. in the Scottish Midlands), while records give an average of 25 days of snow. Sharp frosts are followed by sudden thaws and the frequent changes in temperature continually tend to the disintegration of road surfaces. The great expense of ordinary macadam, tarred or not, on a typical main road is well shown by some figures for a stretch of the Great North Road near Dunblane, given by Mr. W. L. Gibson in his paper on "Methods of Repair and Maintenance of Roads in Scotland." On this road experimental lengths were laid in 1915, since when it is estimated that about 1,000,000 tons of traffic have passed over them. In the eight and a-half years the cost of construction and maintenance per super yard has worked out at 74·27*d.* for ordinary macadam, which gave a life of only two and a-half years and has proved quite unsuitable for main road traffic. Ordinary macadam, tar painted, has cost 105·19*d.*, with an average life of four years. This becomes a most expensive form of road and is only suitable for very light traffic. On the other hand, various systems of macadam grouted with pitch and sand, pitch and oil, tar mixtures, and tarred macadams, showed costs for construction and maintenance per super yard ranging from a figure of 37·9*d.* to 48·23*d.* Most of these lengths have been tar painted six times. All are in excellent condition, and it is impossible to say when they will wear out. For the most expensive the cost of laying was a little less than twice that of plain macadam, while the cost of maintenance was rather more than one-third. The cheapest appeared to be, from Mr. Gibson's figures, macadam grouted with pitch and oil, laid at 16·35*d.* per yard and maintained at 21·55*d.* Tarred macadam surface sealed with distilled tar was a little less costly in upkeep but 4*d.* more in first cost. The standard adopted now for West Perthshire is macadam grouted with 50 per cent. tar and 50 per cent. Mexphalte.

Both Edinburgh and Glasgow have streets mainly laid with setts, though in the former the number of rival systems is considerable. Macadam is, of course, still in use, and this system is laid on 117 miles of streets in Glasgow and 92 miles in Edinburgh. Sett streets, however, aggregate 198 miles in the former and 113·6 miles in the latter. In Glasgow, as is well known, exceptionally heavy traffic is catered for, single loads of 150 tons being taken over the roads. With regard to the use of setts in Glasgow, granite from Loch Fyne and Loch Etive or Welsh granite from Penmaenmawr is used. The setts are about 4 in. by 7 in. by 10 in., laid on a 1-in. bed of sand over a 6-in. foundation of concrete and grouted with pitch. To reduce noise another type of sett is in use, 6 in. by 6 in. by 8 in. or 10 in. deep, finely axed on the top and dressed on the sides, so that they can be laid close. This type of sett has been laid, according to Mr. Thomas Somers, in some streets for twenty years and no repairs have yet been required. On the other hand, Mr. J. R. Findlay stated in his paper that hard whinstone, procured from quarries about 4 miles distant from the city, had been largely used in Edinburgh. A softer quality was used on hills. Aberdeen granite was too expensive to use at the present time, and Norwegian granite was being laid down. A life of twenty-three years was obtainable from hard granite, and after-redressing, another fifteen years.

In neither city is concrete regarded with very much favour. Experience with this material in Edinburgh goes back for thirty years, but has not been extended at all in the past fifteen years. Experimental lengths of rubber paving have been laid in both cities, employing rubber blocks fastened by steel studs to concrete blocks. The rubber

preparation is 2 in. thick and the concrete 2 in. thick, the surface measuring 9 in. by 4½ in. The blocks are laid like setts and grouted with bituminous material. Figures for costs and life could not be given, though Mr. Somers considered it to be prohibitive at present prices; but as regards cleanliness, silence, &c., the results were said to be excellent.

The question of securing greater uniformity of work and maintenance was prominently brought up in papers submitted by Mr. W. S. Whyte, Clerk to the District Committee of the Middle Ward of Lanarkshire, and by Mr. Wallace Fairweather, Chairman of the Upper Renfrewshire District and Roads Committees. The former advocated a consultative council of Scotland, with a view to keeping the country abreast with improvements and securing greater progress than is possible with different interests acting separately. Mr. Whyte considered that greater co-operation is essential between surveyors, and that economies might be secured if some latitude were possible with regard to boundaries, it being frequently possible that it would be cheaper for one stretch of road to be repaired by a neighbouring authority, owing to peculiarities of the boundary demarcation. Some give-and-take, or exchange, as regards upkeep might be arranged in these cases with advantage. Mr. Wallace Fairweather's paper was concerned chiefly with the financing of road work in country districts, but he considered it essential, in order that a proper standard of maintenance should be maintained, that road engineers of standing should supervise the work of local surveyors. This point has several times been raised in our columns, and there is little doubt that there is a considerable weight of opinion in favour of eliminating, or effectively controlling in some way, the participation of small authorities in important schemes. Through no fault of their own, such bodies are handicapped in the matter of road construction, and it would be an advantage if their responsibilities could be placed in other hands.

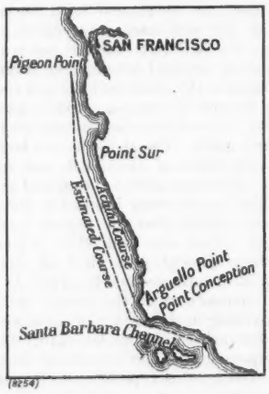
NOTES.

ETHYL-CHLORIDE AS A REFRIGERANT.

IN a paper on "Modern Refrigerating Machines" which Mr. R. G. Reid presented at a meeting of the Institute of Marine Engineers on Tuesday evening, reference was made not only to the common systems of working, but also to the use of ethyl-chloride as a refrigerating substance. The properties of the compound were not completely understood, but machines were now in service in which it was used as the refrigerant. Attainment of the efficiency of the ammonia and carbon-dioxide systems was not possible in general work, but there were particular cases of cooling for which ethyl-chloride was suitable. Conditions for which the system was satisfactory were those in which the use of high pressures was undesirable, and also when there was no necessity to work with extremely low brine temperatures. With condensing water at 90 deg. F., the condenser pressure would average about 30 pounds per square inch absolute, and, as the boiling point of ethyl-chloride at atmospheric pressure was 55 deg. F., a certain vacuum was necessary in the evaporation coils when lower temperatures were desired. Ethyl-chloride was perfectly odourless, and mixed with air it was harmless to human beings, and it had no deleterious effects on food-stuffs. Although it was very inflammable, this was preventible by the addition of other substances. Rotary compressors using ethyl-chloride had proved successful in cases when extreme temperatures were not required and they had been put to service in the passenger cars of many of the leading American railway companies and in steamships and yachts with small or medium-sized plants. In a plant of the reciprocating type, which was recently put into service, the compressor was of the two-stage type. The inlet gas passed in at the side and through the top of the piston by a single inertia valve and was compressed in the top of the cylinder. The delivery valve for the first stage was also fitted in the piston head, and the gas was passed through it into the bottom of the cylinder for the second stage of the compression. The cylinder had, of course, different diameters for the two ends, so that the required ratio of compression in each stage was obtainable. This arrangement was adopted to ensure that the glands were subjected to the highest pressures in order that air leaks were prevented. Forced lubrication was installed for the distribution of glycerine as a lubricant and a separator was installed on the system. Test figures were given by Mr. Reid, showing that the plant had proved greatly superior to the specified guarantee conditions, namely, the elimination of 20,000 B.Th.U. per hour when the brine was cooled from 60 deg. F. to 38 deg. F., and the condensing water entered at 90 deg. F. In the actual test the electrical horse-power was 8·3, the condensing water temperature was 1·6 deg. higher than specified, and the brine was cooled through 33·7 deg. F. instead of 22 deg. F., while the output was 50 per cent. over the specified duty. When cooling brine down to low temperatures was necessary, there was a marked reduction in the value of the method.

DIRECTIONAL WIRELESS SIGNALS AND THE DISASTER TO THE AMERICAN DESTROYERS.

Reliable details have at last come to hand about the disaster to the American destroyers. The problem involved can be reduced to a single question: what degree of reliance is to be placed upon positions at sea fixed by directional wireless observations? The facts are as follows:—the two divisions of destroyers were proceeding down the coast of California, intending to turn into the Santa Barbara channel. During the afternoon, their position was obtained by visual observations of Pigeon point, and a course was then set to carry them clear of Arguello point. When he had checked



his position off this second point, the senior officer intended to carry on a little further and then steer into the Santa Barbara channel, after he had opened up Point Conception. Some time after passing Pigeon point, it came on thick, and the land was no longer visible. Between these headlands there were one or more wireless stations, the positions of which have not been divulged, and the commanding officer checked his position by directional signals from them. By an extraordinary chance, the resulting positions fell very close to the track along which the squadron was estimated to be moving; and this made the commanding officer confident that his position, as calculated by the course and the distance run, was accurate. In point of fact, his squadron was all the time being set eastward towards the land as in the map above. At nine o'clock in the evening, the commanding officer believed himself to be at the mouth of the Santa Barbara channel, whereas he was almost under the cliffs of Arguello point. So assured was he of the safety of his position that he did not wait to take in a further wireless directional signal, and moved eastward; a few minutes later, the ships went ashore. The method of finding positions at sea by wireless directional signals has been learnedly discussed in the 1924 edition of Brassey's Naval Annual, by Professor Eccles, D.Sc., and Mr. Binyon; those who are interested in the subject cannot do better than consult these articles. The point of interest in the details which have arrived is the reliance that American naval officers are prepared to place on this method of fixing a ship's position. The findings of the Court of Enquiry were very severe; but one cannot see in them any express censure of using directional wireless to such an extent. Rather the contrary; blame seems to have been expressed that the senior officer did not use it more freely. According to the rules of British navigational practice, no commanding officer would be justified on such data in making an alteration of course which would carry him towards the nearest land.

LONDON-VIENNA WIRELESS SERVICE.

An important addition to existing means of communication between this country and Central Europe was made on the 12th inst., when the new direct, duplex wireless-telegraph service between London and Vienna was officially inaugurated. The service is operated by Marconi's Wireless Telegraph Company, in conjunction with the Austrian Marconi Company. Messages from this country are transmitted by land line from Radio House, Wilson-street, London, E.C., to the Marconi station at Ongar, in Essex, the signalling currents in the land line being used to operate the automatic signalling keys. Several other services, including those to Canada, France, Spain and Switzerland, are worked from Ongar, but the Austrian service from that station is operated by a valve transmitter of 25 kw. capacity on a wave length of 4,350 metres. The transmission, which can be up to 120 words per minute, is picked up at the receiving station at Laaerberg, 5 miles south-east of Vienna, and relayed over a land line to the central office, situated at 14, Renngasse in that city, whence the individual messages are distributed. Transmission from Vienna to London is carried on through the Deutsch-Altenburg Station, which is situated 25 miles east of the city. This station is controlled from the central office in a manner similar to that employed at Ongar, and the same system of transmission is utilised; the wave-length used is 4,150 metres and the power of the valve-transmitting set is 25 kw. At this end, the messages are received at the Brentwood station and transmitted automatically over a land line to Radio House for distribution. The Vienna transmitting and receiving stations, we may mention, have both been rebuilt and equipped throughout by the Marconi Company, with apparatus designed and constructed at their Chelmsford works. The service, we understand, is now in regular operation and is working with a high degree of efficiency, 10 to 15 minutes being the average time required for the transmission of a message between London and Vienna. An additional wireless service has recently been commenced between the Deutsche-Altenburg station and Berlin, while, later on, similar services will be provided between Vienna and all the principal European cities. In its present state of development, however, the service will be of great utility to all having business dealings with Central European countries, as a considerable saving in time is effected in comparison with telegraphy by land line and submarine cable.

ECONOMY OF OIL ENGINES IN MARINE PROPULSION.

In his presidential address to the Junior Institution of Engineers, which was delivered on Wednesday evening, Sir J. Fortescue Flannery, Bart., reviewed the subject of "Marine Propulsion During Fifty Years." After giving a very comprehensive survey of the development at every stage, he dealt in greater detail with the progress made possible by the introduction of oil fuel. In this phase the president played a large part himself, and therefore his remarks are of importance. What the pioneer workers accomplished is evidenced by the fact that there are now in commission under the British flag about one thousand motor ships and the number is rapidly increasing. When dealing with the great superiority claimed for Diesel engines working on the two-stroke over those of the four-stroke cycle, the president stated that an interesting practical test was in progress with the sister ships Dolgoma and Durenda. These vessels, built for the British India Steam Navigation Company, under the enterprising guidance of Lord Incheape, were engined on the two systems. The indicated horse-power of 4,600, it was calculated, would be produced under both systems with a daily consumption of 15 tons or 0·32 lb. per i.h.p. or, say,

0·42 lb. per s.h-p per hour. These figures have already been confirmed with the four-stroke engines in the Durenda, but accurate results for comparison are not yet available from the Dolgoma. In a round voyage of nearly 27,000 nautical miles which the Durenda performed without a hitch at an average speed of 11·2 knots, the fuel consumption for the main engines was 11·5 tons of oil per day. When contrasted with the 40 tons per day necessary when oil fuel is burned in steam raising and with 70 tons per day when coal is used in the boiler furnaces, the advantages in saving in the weight of fuel carried, were well borne out. That all shipowners are not yet cognisant of all the conditions making for economy of operation was evident from the president's remarks, but the analysis he made of the costs in connection with a specific case provided a wealth of evidence that first cost should not have undue importance attached to it as a factor. Taking a case of a vessel of 9,000 tons d.w., running at 10½ to 11½ knots in service, the Diesel engined vessel would cost 25,000*l.* more than a steamer. If the vessels were run for 250 days per annum the steamer would use 10,000 tons of coal per annum and the Diesel vessel 2,500 tons of oil. The average price of bunker coal, taking 23 representative ports in the world, was recently 2*l.* 0*s.* 4*d.* per ton. The average price of Diesel oil at the same ports was 3*l.* 17*s.* 8*d.* per ton. The annual fuel bill of the steamer was on this basis 20,166*l.* and of the Diesel vessel 9,521*l.*, giving a saving of 10,645*l.* This represented a return of rather over 42 per cent. on the additional capital invested in the Diesel boat. In this calculation only fuel was considered and no account was taken of the gains due to such factors as increased deadweight and capacity, the greater despatch in bunkering operations or any possible savings in total wages of personnel.

LITERATURE.

A Comprehensive Treatise on Inorganic and Theoretical Chemistry. By J. W. MELLOR, D.Sc. Vol. IV. London: Longmans, Green and Co., 1923. [Price 63*s.* net.]

THE admiration excited by the industry and method displayed by Dr. Mellor in the earlier volumes is no whit diminished by the appearance of a fourth volume of this encyclopædic work. The labour of collection and arrangement of the vast mass of facts must have been enormous, and could only have been carried to a successful issue by the construction of a skilfully devised plan. The aim seems to have been to collect the whole of the information scattered through the vast chemical literature of many languages. Doubtless selection has been carefully practised and continually exercised in order to preserve some level of uniformity, and to prevent the work being overburdened by the exhibition of a mass of facts referring to compounds of small importance, or to the results of experiments that have become obsolete. But there is no evidence of any material suppression, and at the end of each section are given references to a number of authorities, bewildering by their multitude and convincing by their reputation. The plan of collection seems admirably adapted to the needs of the specialist, interested in some particular investigation. Here he may learn what has been achieved by many inquirers, how far research has been successful, and what the processes employed. Those not engaged in professional work and who look to broad results rather than to means, may be a little disappointed. One gets the impression, that a complicated mosaic is in course of formation, to which many contributors bring specimens varying in size, in colour, and in shape, not necessarily beautiful in themselves, but which acquire enhanced beauty when fitted into the neatly-jointed fabric of which they will form a part. As a rule we do not see the finished picture, the work of combination has still to be undertaken, if the uninformed spectator is to enjoy the display.

The more familiar one becomes with these volumes and the object of the compilation, probably the more will he be penetrated by the fact that chemistry permeates every science, knowing no limits for its mechanism or its activities. While on one hand by the reading of spectra, it will define the constitution of the stars and of distant galaxies, by its interpretation of the phenomena of radio-activity it is equally prepared to construct the invisible atom and to busy itself with the laws of disintegration and transmutation. The infinitely great and the infinitely minute fall equally within its purview. Further, since the ultimate purpose of all science is to minister to the wants and to increase the welfare of mankind, this wide reaching science plays a large part in our daily lives, individually and collectively. There are no boundaries and no divisions. Physics on one side as biology on the other claim a share in the utilisation of chemical knowledge, and at the same time, these sister sciences react on chemistry, widening its aims and supplying further means for enlarged inquiry.

Dr. Mellor opens this volume with a description of the radium and actinium families, prefacing the section with a review of the fascinating and complex theories that have centred round the structure and behaviour of the atom, and concluding it with reference to Sir J. J. Thomson's electronic theory of matter and the architecture of the electrically neutral atom. He devotes about one-fifth of his entire space to the work undertaken in consequence of the discovery of radioactive phenomena, and the wealth of material at his disposal taxes even this liberal allowance. He has to trace the steps of an involved theory, in which both argument and inference figure largely, making the order of presentation a matter of prime importance in assisting the reader to draw a conclusion from so many facts and converging lines of argument. The unitary theory of matter and the support that recent investigations have given to Prout's hypothesis does not seem a very convenient place to view the structure reared on the physics of atomism, for Moseley's work, demonstrating the high probability that the elements are built up from one another by successfully adding the nucleus of the hydrogen atom was of much later date. On the other hand, reference to the work of Sir J. J. Thomson on the electronic theory of matter and of the evidence of the inertia possessed by an electric charge is banished to nearly the end of the article, but here we write subject to correction, for the index is not very satisfactorily arranged, since it contains no systematic reference to the names of authors. Many names closely connected with valuable developments of the theory are not mentioned at all, and others insufficiently described. This perhaps is of less consequence as the accumulation of evidence has raised the atomic hypothesis to the position of a scientifically well founded theory, and the researches of many workers are merged in a common result. While testing the index we looked for hafnium, and it does not appear, from which we conclude that Bohr's rational explanation of the periodic table is denied any support from the recent discovery of this metal, whose properties are found to correspond to his predictions.

The other elements which come under review in this volume are beryllium, magnesium, zinc, cadmium and mercury. The scheme which Dr. Mellor originally proposed to himself, to describe all the compounds known in inorganic chemistry is seen to be a gigantic task, but he does not flinch from it. In treating of beryllium, or glucinium, for his careful examination of the history of the discovery does not permit him to decide which is the more correct or fitting title, he quotes a remark due apparently to C. L. Parsons, "that the literature of inorganic chemistry is overburdened with compounds, which have no actual existence, but which have obtained their place and been assigned formulæ simply from the analysis of solid phases, obtained under variable conditions and without other attempt to prove their individuality." This quotation implies that the author is aware of the danger of including irrelevant matter, and exercises a cautious discrimination. Rejection has no doubt been as severe a task as selection. To justify the inclusion of an extract, it has to be examined and tested, its value ascertained and its usefulness verified.

Magnesium, from having been studied by many early chemists, who found Epsom salts a convenient subject for experiment, has collected round it much literature of questionable value. Of this we are reminded as we try to follow the author through the long succession of oxides and fluorides, bromides and iodides, chlorides and sulphides, but grow restive when introduced to the complex double salts of magnesium sulphate. In the mass of detail the remarks on dolomite make a welcome resting place where we may contemplate chemistry on a large scale, and avoid the niceties of alternative preparations.

Zinc is a common metal, but its industrial importance in uncombined forms is of quite recent growth. Cadmium, which the author joins with it as part of the sub-chain from magnesium to mercury, is comparatively rare, and could hardly have been detected till zinc was smelted on a large scale, when it was found in the fine dust accumulated in zinc furnaces. The usual extraction of cadmium still consists in recovering it from the zinc fumes by mixing them with charcoal, whence it may be distilled fractionally. The various salts and combinations of these metals with other elements are traced through their various forms with the same detail shown in the case of the other metals. Mercury, the last element in the chain, is subject to an exhaustive treatment, and its connection with zinc and cadmium is carefully scanned. Dr. Mellor thinks it possible that there may be a missing member between cadmium and mercury, since the steps in the chain are uneven, the gap between cadmium and mercury being greater than between zinc and cadmium. The differences to be noted are as distinct and important as the similarities. Dr. Mellor states that the properties of the mercuric salts differ very considerably from the salts of any other metal, but it is very difficult to collect the evidence and view it as a whole. The compilation of such a work as the present makes the task easier. The completion of this comprehensive view over the whole of inorganic chemistry will be eagerly anticipated.

Electrical Engineering Practice: A Practical Treatise for Electrical, Civil and Mechanical Engineers, with many Tables and Illustrations. By J. W. MEARES, C.I.E., and R. E. NEALE, B.Sc.(Lond.) Fourth edition. In two Vols. Vol. I. London: Chapman and Hall. [Price 25*s.* net.]

THIS book has passed through several editions, each bringing some extension of old matter, and the introduction of new, continually increasing the bulk, till it has now arrived at the dignity of two volumes, only one of which has yet appeared, permitting but a very partial view of the entire scheme of the authors. The portion, however, that is seen is very satisfactory, and that which is to follow dealing with the application of electricity to industrial purposes, should offer even greater attractiveness, for definitions and much of the preliminary matter which it is thought to be necessary to offer at the outset have been presented in every possible light, and by so many authorities, that opportunities for the creation of fresh interest or for the exhibition of originality of treatment are difficult to find. Passing over those technical terms whose significance is very inadequately appreciated till they are found to be necessary in actual application, we have a chapter on materials, treated far more fully than is usual in elementary works. As specialists in electrical engineering, the authors can see only two groups of materials, conductors and insulators. The recognition of varieties and qualities among these leads however to further discrimination, and other physical properties serve as the bases for more elaborate classification. Many metals and alloys, various slates and glasses, resins and synthetic products, are shown to be suitable for particular purposes by reference to their thermal characteristics, their mechanical properties, their dielectric strength or their chemical composition.

From the nature of materials we pass to instruments and the methods of measurement. Here, again, a system of classification, which adds much to clearness, is followed, according to the effect the current produces, whether electrochemical, thermal, electromagnetic or electrostatic. Dielectric breakdown is included among the types of instruments suitable for measurement, but this is hardly an instrument in the ordinary acceptation of the term, though of course there is a relation to be determined by experiment between the voltage and the length of spark gap which it will break down.

The chapter on methods of measurement concludes the first section, and the second opens with

the so-called generation of electricity, a term which the authors use after due apology and explanation. It would have been sufficient, perhaps, if attention had been confined to those sources of electricity which are due to electrochemical effects, arising from the use of primary batteries; and from dynamo electric generators, since the authors claim to give only the information that is useful in practice, but the piezo effect, thermo-couples, and electrostatic generators all find mention, though only the last can have slight commercial importance. On the practical side, however, while in company with primary cells and dynamos we are on well-trodden ground, and it would be difficult to point to any pertinent remarks that are not to be found in similar treatises. The point that is most satisfactory to notice is that the authors maintain a well proportioned balance, neither omitting what is elementary and fundamental nor indulging in occasional attempts to reach those greater and alluring niceties, that are apt, however, to prove bewildering. A standard of average level is maintained, the difficulties are not shirked, while the practical rules and hints for commercial working are much to the point. On the other hand, it may perhaps be urged that the authors are travelling out of the record when they discuss the possibility of direct utilisation of solar heat to raise steam in large area boilers, at the focus of reflectors, though we admit that the system has its advocates and has been applied mechanically to such good effect, that one installation at least could compete economically with coal heated boilers, when the price was 70*s.* per ton.

The use of mercury vapour in a thermo-dynamic cycle is mentioned—we can hardly say is recommended—as a possible means of raising the upper working temperature and thus increasing the possible efficiency without employing high pressures. Theoretically the plan is sound, and the authors are able to point to one commercial station, that has an oil-fired mercury boiler containing 30,000 lb. of the metal. The price of mercury a few years ago would have made the expenditure prohibitive in this country, and in using a mineral of which the world's supply is small, there is always the danger of scarcity, real or simulated. The boiling-point of such a fluid permits operations in a range of temperature above that of the usual steam cycle without much increasing atmospheric pressure. Its high specific gravity facilitates the gravity feed, the sealing of valve stems and centrifugal sealing of turbine packings. Mercury is neutral to air, water, iron and organic substances, and the vapour density is so high that the "spouting" velocity is low and a very simple type of turbine can be used. All this and much else may be admitted, but the employment of mercury seems to be an expensive luxury, and our only object in referring to this among many similar items, is to show the minuteness with which the technical journals have been ransacked for novelties and experiments.

Three chapters are devoted to the possibilities of water at different levels as a source of power, and this space is not too great if the interest inherent of the subject and the eagerness to use this form of energy are taken into account. The Indian experience of one of the authors lends additional weight to the conclusions deduced. Much of the first chapter is devoted to the dynamical side of the inquiry. Schemes are being worked out with more thoroughness than is exhibited here, but those who are deploring, in season and out of season, the neglect shown in this country to the installation of low-power plant, cannot be too frequently reminded of the difference in capital cost per unit of power, from high and from low heads. With a head of approximately 1,500 ft., with a capacity of 2,000 kw., the authors reckon the approximate capital cost at 30*l.* per kilowatt, while a low head of, say, 25 ft. and 200 kw. capacity, requires a capital cost of 100*l.* per unit. Of course, this estimate does not touch the ultimate cost of steam and of hydroelectric power, for though the initial cost of the latter is high, and the interest charges heavy, the working expenses are lower and almost independent of load. The question is rather too large to be discussed in an elementary work like the present, but it seems not improbable but that the price of coal will be the decisive factor in many of the schemes now under consideration, such as that of the Severn barrage. As the probabilities point to a higher rather than to a lower price of coal, hydroelectric power may come into its own even in this country of modest rivers and easy gradation. The final chapter in this section on electricity costs and tariffs is of interest to the public, as well as to the electrical engineer.

Having generated the electricity it is next necessary to transmit the power, and the last section of this volume is devoted to considering the insulation of wires and cables, the overhead and underground transmission of power, the protection of circuits and apparatus and to the functions of switch gear and the switchboard. The interest has increased with the progress of the book, and the student who has followed the instructions up to this point should have a fair practical knowledge of the working of circuits. The authors have covered very considerable ground and described the working of many recent developments. In these last chapters, to which we can make only the briefest of references, will be found a very instructive note on the Thury constant current system which offers an economical solution for some pressing problems, where ordinary methods of transmission are either undesirable or impracticable. The remarks on the protection of circuits and apparatus are well deserving of consideration, for it is to be feared that in many cases ignorant interference with the devices intended to ensure safety has utterly destroyed their protective value.

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FLOODS OF THE DAMODAR RIVER AND RAIN-STORMS PRODUCING THEM.*

By ERNEST LESLIE GLASS.

THE Damodar river, a tributary of the Hooghly river in Bengal, has a catchment-area of 8,200 sq. miles, 7,200 of which are in the hilly districts of Chota-Nagpur, rising in places to an elevation of over 2,000 ft., while the remainder is a flat deltaic area from 10 ft. to 100 ft. above sea-level, where for the last 135 miles of its course the river is partially embanked and where destructive flood spills have always been a trouble.

A prolonged series of gaugings of storm rainfall and flood flow has been maintained by the Bengal Government, which affords a valuable record of the flood conditions of the upland portion of the Damodar catchment. A large affluent, the Barakar river, with a catchment-area of 2,650 sq. miles, joins the main river just before it emerges on to the flatter country at the head of its alluvial plain, where the intensities of floods depend very largely on the coincidence of flood-crests of the Barakar and Upper Damodar branches.

Gaugings of floods have been observed and recorded since 1857 at gauges erected at two sites, namely, Raniganj and Edilpur. The former is 22 miles below the junction of the Upper Damodar and Barakar. The river does not spill over its banks upstream of this gauge site, and here it has a stable channel with hard well-defined banks. The records show that prior to 1909 only two readings were taken daily at 6 a.m. and 6 p.m. Since 1909, however, and more markedly since 1913, valuable records of the peaks and rise and fall of all floods have been obtained at this site. The second station, at Edilpur, is 53 miles farther downstream: here, since 1857, the gauge-readings have been observed more carefully. Unfortunately, this site is not suitable for use in calculating the discharge rates for the following reasons: (1) The river here has a wide sandy bed and shifting channel. (2) Floods overtop the right bank for a length of 10 miles upsteam. (3) The effect of silting of spill areas below Edilpur and of flattening of bed-slope has also been gradually to tighten up the channel and therefore raise the level of floods at Edilpur. Two Bengal engineers who have made special studies of the Damodar floods have stated that since 1885 the mean flood-levels for consecutive 10-year periods at this Edilpur site have risen uniformly at a rate of about 1 ft. 2 in. in 10 years.

The relation between the gauge-readings at Edilpur and those at Raniganj for the same floods varies not only for various floods during 1 year but varies from year to year as the régime of the river below Raniganj is changing. An attempt has been made to plot a curve from existing data which will give a fairly accurate relation between gauge-readings at Edilpur and Raniganj for similar flood-discharges passing Raniganj. The average of the peak discharges at Raniganj of all maximum floods experienced during each year for the period of 62 years, 1857–1918, was 250,000 cusecs. Normal floods range from 200,000 to 300,000 cusecs with a year-maximum frequency of about 55 per cent. Floods exceeding 400,000 cusecs are extremely abnormal. Abnormal floods range from 300,000 to 400,000 cusecs, having a frequency of 21 per cent. The frequency of years of sub-normal floods below 200,000 cusecs is about 22 per cent.

A diagram of the total monsoon flow at Raniganj for each of five consecutive years 1913–1917, a period which contains one of each type of flood and includes a year of abnormally heavy rainfall (1917), shows that abnormal floods with peak discharges exceeding 300,000 cusecs are not likely to occur more often than once a year. Normal floods (from 200,000 to 300,000 cusecs) may occur several times during a year. The normal monsoon flow of the river seldom exceeds 200,000 cusecs, being generally between 50,000 and 150,000 cusecs, and the volume of flow at high flood stage is generally small compared with the total volume of monsoon flow.

Curves of flow at Raniganj of nine floods give the discharges and periods as worked out from gauge-records.

Rainfall Records.—Records are available of 25 gauging-stations in and around the catchment-area for a period of about 26 years. Observations are, however, taken only once daily and give no information as to intensities of fall. Rainfall contours have been plotted on a map of the catchment for the rainstorms corresponding to several of the floods.

Combining the information obtained from these charts with that given in other records, all the available details of seven storms and of the resulting floods have been compiled. Floods are caused by rainstorms lasting for three to six days. The total mean rainfall on the entire Raniganj catchment which produces floods generally ranges from about 3 in. in three days to a maximum of about 12 in. in six days. The volumes of rainfall on the catchment during flood-producing storms range from about 50,000 million cub. ft. to a maximum of about 200,000 million cub. ft. The percentage of discharge to rainfall for such storms ranges from about 55 to 85 per cent. The duration above 50,000 cusecs of separate single floods varies from about 60 hours to a maximum of about 192 hours.

An effort has been made to arrive at an estimate of the probable maximum flood by studying the intensity and distribution of the total rainfall during large storms in the locality of the Damodar catchment. The daily rainfall records are available of two exceptionally large storms that occurred in August, 1913, and August, 1917, producing heavy floods in the Damodar that have been observed in detail. With these data the contours of the high rainfalls have been drawn, and they indicate very

* Abstract of paper to be read before the Institution of Civil Engineers on Tuesday, January 22, 1924.

strikingly that the heaviest rainfall of the great storms of August, 1913, and August, 1917, was well outside the Damodar catchment, and that had the centres of these storms been inside the catchment, very much larger rainfalls and floods would have been experienced.

To ascertain what these extreme possibilities are for the 1913 and 1917 storms, time-area-depth curves have been prepared from planimetric measurement of the areas within and between contours, and from calculation of the mean depth of fall over the area within each contour. From these curves have been deduced the maximum 3-day and 5-day falls that occurred during the 1913 and 1917 storms on various areas. The author feels confident that these storms are really about the largest that do occur in this locality, having regard to the long record of the Damodar floods the outstanding nature of the 1913 flood, and the fact that the figures obtained from the rainfall contours of these storms about equal those of the largest of 114 great storms of the southern portion of the eastern United States which have been studied by the Miami Conservancy Board engineers.

THE EFFECT OF SHAPE OF CATCHMENT ON FLOOD DISCHARGE.*

By LIEUT.-COL. GORDON RISLEY HEARN, D.S.O., R.E., Assoc.Inst.C.E.

THE author has studied the question of flood-discharge, which is attracting increasing attention, for over 20 years, in the course of the projecting of railways in India, his attention having first been directed to the difficulties surrounding the estimation of floods by litigation which followed a serious accident on the Madras Railway in 1902. He has recently had to determine the area of waterway in a number of culverts for the Khyber Railway in a country where rain seldom falls, but where severe, though short-lived, floods result.

Most of the formulas which have been propounded from time to time are believed by the author to be founded on wrong assumptions, or to rely on too many factors difficult to estimate. In particular, the framing of Dickens's formula is shown to have been based on an accidental coincidence, taking no account of differences in physical aspects of catchments. To arrive at the estimation of the discharges on the Khyber Railway the author has analysed results obtained on the torrents flowing off the Pabbi Hills and crossing the Upper Jhelam canal in the Punjab. The results obtained during construction by the calculation of open-channel discharges appear to have been confirmed by afflux observations subsequently, although the allowances given exceeded in certain catchments 2,000 cusecs per square mile.

The author is averse to the propounding of a formula, since he considers that such a formula must have limitations, but he has drawn a curve limited to about 10 sq. miles, which gives the probable relation between intensity of rainfall and area. The formula for this curve is Q (cusecs) = 640 A (4 — log A), where A is in square miles: but this formula does not apply to 20 or 100 sq. miles.

In certain formulas it has been suggested that the maximum intensity of rainfall is some fraction of the annual rainfall, but the author has collected a number of surprising figures which go to show that there is no such relation, and, indeed, that a great intensity may occur in the British Isles as readily as in the Tropics. Again, the occurrence of severe floods in arid tracts is not uncommon. The statistics of downpour collected are shown graphically, but are incomplete owing to want of figures concerning the Louth (Lincolnshire) storm of May, 1920, which is believed to have been extraordinarily severe for any part of the world. The decrease of intensity with time of fall is shown by many records.

The author gives particulars, including the discharge, of a number of small catchments which he has investigated, among which are the Pabbi torrents and a river in Khandesh draining 215 sq. miles, the discharge from which approximated 1 in. per hour. In giving these particulars he draws attention to the shape of these catchments. He proceeds to examine the factors affecting discharge, which he classifies into two main factors, namely, soil-slope protection,† and shape. The effect of the latter is well brought out by the analysis of the Pabbi torrents when classified by their shapes—triangular, elliptical, and balloon-shaped, the latter giving a much increased discharge when the upper part is nearly semicircular. This appears to be due to concentration, but probably is also due to such catchments having a shorter "time." This point is discussed in the paper.

The slopes of the Pabbi torrents are peculiarly conducive to severe flooding, since the upper portions of the catchments are comparatively steep, whereas the lower portions approaching the canal have easier slopes; but the effect of shape appears to overrule any inference to be drawn from the slopes. At the same time the multiplying factors for the effect of shape, as inferred from the analysis, appear to be very high, attaining 2·5 for semicircular catchments, compared with the ordinary triangular catchment taken as unity. This, of course, gives the maximum at the crest of the flood and not the average. The factors to be applied are debatable.

In the hope that the factor of shape may receive wider recognition, the author suggests the form of an exhaustive questionnaire to be filled up as far as possible when recording details of flood-discharges for communication to the Press or scientific institutions.

The particulars required are as follows:—(*a*) Area of catchment, length, greatest width and position in regard to length, distance to point of concentration above culvert, general shape of catchment; (*b*) general elevation of catchment, whether abutting on the main range, slopes to main stream, slopes of bed of main stream; (*c*) nature of soil in upper parts of catchment, protection or terracing, absorption in bed of stream, obstructions by winding or otherwise; (*d*) area of storm, direction and rate of travel, height of clouds, time of rain falling, intensities maximum and average, time of rain ceasing; (*e*) maximum flood at crest, time of first flow of water, time of crest, time of ceasing.

The author believes that the effect of shape, the effect of change of slope, and the proportion of discharge during exceptional rainfall, are subjects for debate and for continuous research, which will be much aided by the contribution of all available information. He believes that the omission of particulars of shape of catchment renders it difficult to obtain full value from published records of floods.

* Abstract of paper to be read before the Institution of Civil Engineers on Tuesday, January 22, 1924.

† *See* author's "Railway Engineer's Field Book."

DISCHARGE FROM CATCHMENT AREAS IN INDIA AS AFFECTING THE WATER-WAYS OF BRIDGES.*

By GEORGE ERNEST LILLIE, F.C.H., M.Inst.C.E.

IN the present state of knowledge the estimation of the maximum discharge from a river or stream is a very unsatisfactory business, whether the calculations be based upon the reputed highest flood-level or on one of the discharge formulas. After many years of work the author has ceased to feel any confidence in calculations made on the former basis unless confirmed by independent evidence. On the other hand, most of the discharge formulas are essentially unsound and cannot be relied on. As the results of careful study during the last 28 years, the author believes that a better formula could be devised, which would at least have the advantage of giving less erratic results than the other method.

The best of such formulas at present is Craig's, but it is far from perfect and is very difficult to apply.

The object of this paper is to take up the question where Craig left it. The maximum rate of discharge depends upon the size and shape of the catchment, the rainfall, the character of the ground, and the general slope of the country. The discharge D at any point equals the sectional area of the river, S, × the velocity of flow, V. The steeper the country, the more rapid will the flow be, and, the process of discharge being accelerated, the maximum rate of discharge will be high. In other words, D and V vary, S remaining constant. A local change of the slope of the river, on the other hand, cannot affect the rate of discharge, for S and V vary, D remaining constant.

The fact that S is independent of the general slope of the country in which the catchment lies, indicates that it would be better to devise a formula for S rather than D, as in that case the formula would be independent of the general slope. In developing the formula in this paper, however, arguments are used, as a matter of convenience, which relate to D; but in such cases it is assumed that the general slope of the country does not vary.

Shape and Size of Catchment.—The remote parts of an area do not affect the maximum rate of discharge to such an extent as the nearer parts, on account of absorption and evaporation losses and the time taken by the discharge to traverse the area. Hence the contribution from an element of area *dw* to the maximum rate of discharge is $\frac{dw}{y}$, *y* being the distance from the discharge-point. The maximum rate of discharge is thus $K\int\frac{dw}{y}$, an expression which gives a variation in the discharge for various sizes of catchments (the shape remaining the same) as $\sqrt{\text{area}}$. For very small catchments, however, the maximum rate of discharge is clearly proportional to the area of the catchment. As the area considered increases, the rate of variation in the discharge decreases, gradually at first, until the area reaches what may be regarded as the maximum covered by a single phenomenal shower. Above that, the rate of variation gets rapidly less, becoming for very large areas proportional to the square root of the area, and agreeing with the above expression.

The variation of D in Craig's formula, between these limits, for all shapes and sizes, is as L (1·1 + log L), L being the length of the catchment. The author's proposed formula is based on the expression $\int\frac{dw}{y}$, which accounts for the shape of the catchment; and, in order that the variation for all sizes and shapes shall be as L (1·1 + log L), the factor λ is added. As $\int\frac{dw}{y}$ varies as L, λ becomes (1·1 + log L). To apply the expression $\int\frac{dw}{y}$ the catchment must be divided into sectors of circles with centres at the discharge-point. This results in a formula:—

$$S = R\lambda\Sigma(\theta L)$$

where R is a rainfall factor, and θ and L are, respectively, the central angle and the length of the various sectors, and λ is as above.

Rainfall and Character of the Ground.—The maximum rate of discharge is affected by two sets of phenomena; one set is affected by the annual rainfall, and the other is independent of it. Of the latter the most important is the extent and duration of a phenomenal downpour; and it appears that such downpours are as likely to occur and to be as severe in dry as in wet districts, although, of course, not so frequent. If the results of the two sets of phenomena are denoted by A and Q, A being constant and Q varying with the annual rainfall, the maximum rate of discharge is D = K (A + Q). From this the rainfall factor R is determined, and $R = 2 + \frac{I}{15}$, where I is the annual rainfall of the district considered. Tabulated values of R and λ are appended to the paper.

Ordinary high floods will approximate very closely to the potential maximum given by the formula in the case of large rivers; but in small streams the difference will be great. Rivers in flat and absorbent countries will not, in ordinary years, approach their potential maximum discharge. The failure of the aqueduct over the Kala Nada, in 1885, is an example of the result of basing the design on ordinary high floods instead of on the potential maximum. This actually occurred in that year when the flood section was more than five times as much as in ordinary high floods, and agrees with the figures given by the author's formula.

This formula is applied to thirteen cases of rivers of all sizes in various parts of India.

* Abstract of paper to be read before the Institution of Civil Engineers on Tuesday, January 22, 1924.

PULVERISED FUEL FOR POWER-HOUSE PLANTS.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with great interest the discussion in our technical press which has followed the reading of Mr. Brownlie's paper. It is surely not in dispute that pulverised fuel as a means of firing power-house boilers has been rendered a success in America and elsewhere, and that all grades of coal can be applied with many advantages in this manner.

It also appears to me to be not so much a question of comparison between the efficiency of firing with mechanical stokers and that of pulverised fuel firing, for this figure at normal full-load rating of boilers is in either case approximately equal. What is of outstanding advantage in pulverised-fuel firing is the collective result of boilers standing by with fire chambers closed and no banked fires—a real economy in itself with little or no loss of steam pressure—the facility afforded to use small coal of equivalent heat value to larger lump coal, the ability of a pulverised-fuel fired boiler to take normal load or forced overload to a very high figure. The latter advantage makes it possible to curtail expenditure on boiler plant by at least half the amount required for stoker-fired boilers, with consequent reduction in capital charges for current generated.

These collective advantages must carry weight when the capital and operating cost of a power plant is under consideration, and they appear to have been lost sight of in the discussion which has taken place relative to efficiencies with mechanical stokers and pulverised coal-fired boilers, and to the one "system" of pulverised-coal firing mentioned.

Pulverised-fuel firing has advanced for all approved applications beyond any oneso-called "system," which is entirely a misnomer. There are but few, if any, patents of exceptional value. It is now a broad art in the development of which a very wide choice of plant has become available, and it is only a matter of accepting the proved results of both plant items and of the recognised effective applications of pulverised fuel to see whether this method of using solid fuel outbids any other method for any one particular purpose.

The use of fuel in pulverised form has added another efficient means of applying coal to best advantage under prescribed and suitable conditions. One such purpose which has won for itself undoubted success is that of its application to large power-house boilers, in view of the above advantages, the relatively small volume of flue gases, and the absence of smoke.

I am, Sir, yours faithfully,

LEONARD HARVEY.

25, Victoria Street, Westminster, S.W. 1,
January 10, 1924.

STRESSES IN REINFORCED PIPES.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the highly interesting article by Dr. Gilbert Cook on "The Stresses in Pipes Reinforced by Steel Rings,"* I beg to present with this a brief synopsis of a series of essays and results, referring to the same problem. It seems practical not to restrict myself to internal pressure but to consider external pressure as well.

This problem is the more complicated as, besides the determination of the complex stress it is also necessary to consider the elastic stability of the thin "shell" forming the tube, *i.e.*, to determine the critical pressure under which it will collapse, respecting the "critical length" *l* between the rings for a given pressure. This problem was solved in 1914, *cf.* sub 6.

1. A. E. H. Love's "Treatise on the Mathematical Theory of Elasticity," Vol. II (first edition 1893) gives the "main differential equations" on page 317, of article 385 (Strength of Cylindrical Shell) but in a more general form, with a longitudinal stress P_1 added and also a complete solution for certain boundary conditions. It is necessary to consider this longitudinal stress also with the pipes because it is different from zero and influences the elastic displacements *z* by the action of lateral

* See vol. cxvi, page 477.

contraction (*see* paragraph 7). Furthermore, the following conclusion is drawn (page 315) about boiler flues.

"The most important practical conclusion regards the spacing of the joints by which the flue is protected against collapse. We have the rule—the ratio of the distance between consecutive joints to the mean proportional between the thickness and the diameter must not exceed a certain limit. The limit should be determined by experiment.

"The practical rule adopted by engineers (I am indebted for information on this subject to Mr. W. H. Maw, Editor of ENGINEERING) is to make the distance between the joints a certain multiple of the thickness (frequently about 100 for a pressure of 90 lb. wt. on the square inch), and it is customary to diminish the ratio of these quantities when the working pressure is increased. The theory here given suggests nothing in regard to the change to be made in the spacing of the joints for a given change of pressure, but it suggests a modification of the rule for spacing the joints when the pressure is given."

A. E. H. Love, in the second edition of his "Treatise" (1906) page 530, writes :—

"It would appear therefore that, in flues of different sizes, the rule for spacing the joints, by which the flues are protected against collapse, ought to be: The distance between the joints should be proportional to the geometric mean between the thickness and the diameter." (*Cf.* sub. 6.)

2. Fr. Engesser, Ueber die Knickfestigkeit von Ringen und Röhren (Centralblatt der Bauverwaltung, 1888, page 307) seems to be the first, who has attacked the problem of external pressure by purely analytical means. He gives the following formulae :—

$$p = \mathrm{E}\,\frac{t^3}{\mathrm{R}^3}\left(\frac{1}{3} + \frac{\pi^4\,\mathrm{R}^4}{36\,l^4}\right),$$

$$\text{if } t \text{ and } \frac{d^2 t}{d x^2} = 0 \text{ for } x = 0 \text{ and } x = l$$

and

$$p = \mathrm{E}\,\frac{t^3}{\mathrm{R}^3}\left(\frac{1}{3} + 5\,\frac{\pi^4\,\mathrm{R}^4}{36\,l^4}\right),$$

$$\text{if } t \text{ and } \frac{d\,t}{d\,x} = 0 \text{ for } x = 0 \text{ and } x = l.$$

3. A. Stodola "*Die Dampfturbinen*," 2nd edition (1904) says on page 131 :—

"The stress in the 'free' drum becomes therefore too high for ordinary materials if the circumferential velocity is increased above about 330 ft./sec.—400 ft./sec. Stiffenings in form of spokes, or still better, of solid discs, must be provided. They must be close together, however, if they are to be effective."

The fourth edition (1910) also contains the "main differential equation" (page 596) but does not advance to a complete solution satisfying the boundary conditions. It only recommends the introduction of special numerical values as early as possible.

4. H. Müller-Breslau, "*Graphische Statik der Baukonstruktionen*" (Vol. II, part 2, page 252 ff.), H. Reissner, "Beton und Eisen" (1908 page 150 ff.), Panetti, "Studio statico dei serbatoi cilindrici in ferro ed in cimento armato" (Giornale del Genio Civile, Marzo 1906), Pöschl u. Terzaghi "Berechnung von Behältern nach neueren analytischen und graphischen Methoden" (1913). All these works are relating to vessels standing upright, and the last mentioned brings the theory to a certain perfection. Firstly, it states the "main differential equation," for considerably more general cases ($\mathrm{P} = \mathrm{F}(x)$, $t = f(x)$, $\sigma = \phi$ (ε)) and solves it completely for a series of boundary conditions. On page 9 it says: "The entire elastic behaviour of the vessel only depends (in the Terms used in Dr. Cook's 'article') on

$$k = 12\,\frac{m^2 - 1}{m^2}\,\frac{l^4}{\mathrm{R}^2\,t^2} = 4\,n^4\,l^4.$$

"All vessels with the same value of k are elastically equivalent."

5. R. Lorenz, "Die Berechnung rotierender Trommeln" (Zeitschrift des Vereins Deutscher Ingenieure, 1910, p. 1397) gives :—

(*a*) The main differential equation in the case of longitudinal stress $\mathrm{P}_l = 0$ and $m = \infty$," the action of the lateral contraction being neglected.

(*b*) Similar curves as in Fig. 2 of the "article" are plotted (Figs. 3 and 4), and

(*c*) The following conclusion is drawn on page 1399, translated into Dr. Cook's terms :—

$$\sqrt[4]{\frac{3}{t^2\,\mathrm{R}^2}}\,l = n'\,l \quad \text{should be} < \frac{3}{2}\,\pi$$

i.e.,

$$l < 3{\cdot}58\,\sqrt{t\,\mathrm{R}}$$

(as against $l < 3{\cdot}66\,\sqrt{t\,\mathrm{R}}$ in the "article"), "if the stresses in the drum are to be less than in a ring which is freely rotating" (that is a drum without stiffening discs).

This seems to be the first time that a definite value is given.

(*d*) It is shown, in what way the dimensions of the drum can be chosen in such a manner, that the stress q_0 (for $x = 0$ and $x = l$), becomes equal to the stress q^1 for $x = \frac{l}{2}$, so that a kind of drum of "uniform strength" results.

6. R. v. Mises, "The Critical External Pressure of Cylindrical Tubes," (*Zeitschrift des Vereins Deutscher Ingenieure*, 1914, p. 750) starts with A. E. H. Love's general equations for thin plates and shells, and supplies a generally applicable formula for the critical pressure (respecting the critical length l under a given pressure) of which Love still had to say in 1893 (II edition p. 530). "An exact numerical value cannot be obtained."

7. The author of this article (formerly with the Krupp Shipyard, Kiel-Gaarden, Diesel Engine Department), corrects the values in Mr. R. Lorenz's paper by introducing in the calculation the lateral contraction according to Mr. Love's general equations (*Zeitschrift des Vereins Deutscher Ingenieure*, 1910, p. 2061). In a later article ("Werft und Reederei, 1920, p. 163 ff.") he has given a detailed summary of the whole problem with many explicit formulæ for the stresses in reinforced vessels under internal as well as external pressure. The action between the rings (called "frames") and the cylindrical shell is fully discussed and the values of the stresses are given in terms of the area of the cross section and the width of the stiffening rings, *cf* Fig. 23, p. 195, and equation (ϵ^1). The longitudinal stress is taken into consideration if different from zero, and it is shown (p. 219 equation II) that the pressure P is to be multiplied by $\frac{2\,m - 1}{2\,m}$ = 0·85 in this particular case, a decrease of the elastic displacements and consequently of the stresses being the result. This factor should evidently be added on the right side of the "main differential equation" of Dr. Gilbert Cook.

On the other hand, the highly interesting problem of reinforcing by rings under initial tension, seems to have been treated for the first time by Dr. Cook.

The whole set of formulæ in the "Werft und Reederei," paper originated in 1917-18 when the writer of this article was engaged in the calculation of submarine hulls. His work resulted in certain constructions which were patented. Some of the results of a series of actual tests and a detailed discussion of the minimum-weight-problem have appeared in the magazine "*Werft und Reederei*," 1921, p. 505.

The subject has been recently investigated further by the author in the "*Mechanisches Seminar der Technischen Hochschule Karlsruhe*" where the following solutions were obtained to satisfy a symmetric boundary conditions (in terms of the "article") :—

a^0 If $\frac{d\,t}{d\,x} = 0$ and $t = t_0$ for $x = 0$

and

$$\frac{d\,t}{d\,x} = 0 \text{ and } t = t_2 \text{ for } x = l,$$

$$t = \frac{\mathrm{R}^2\,\mathrm{P}}{\mathrm{E}\,t} - \left(\frac{\mathrm{R}^2\,\mathrm{P}}{\mathrm{E}\,t} - t_0\right)\Big(\cosh n\,x\cos n\,x - \mathrm{H}_0\cosh n\,x\sin n\,x - \mathrm{L}_0\sinh n\,x\sin n\,x\Big) - \left(\frac{\mathrm{R}^2\,\mathrm{P}}{\mathrm{E}\,t} - t^2\right)\Big(\mathrm{H}_2\sinh n\,x\cos n\,x - \mathrm{H}_2\cosh n\,x\sin n\,x - \mathrm{L}_2\sinh n\,x\sin n\,x\Big)$$

where

$$\mathrm{H}_0 = \frac{\cosh n\,l\sinh n\,l + \cos n\,l\sin n\,l}{\sinh^2 n\,l - \sin^2 n\,l},$$

$$\mathrm{L}_0 = \frac{\sinh^2 n\,l + \sin^2 n\,l}{\sinh^2 n\,l - \sin^2 n\,l}$$

$$\mathrm{H}_2 = \frac{\cosh n\,l\sin n\,l + \sinh n\,l\cos n\,l,}{\sinh^2 n\,l - \sin^2 n\,l}$$

$$\mathrm{L}_2 = \frac{2\sinh n\,l\sin n\,l}{\sinh^2 n\,l - \sin^2 n\,l}$$

Evidently, if $t_2 = t_0$, $\mathrm{H}_0 - \mathrm{H}_2$ and $\mathrm{L}_0 - \mathrm{L}_2$ become equal to the values of H and L of Dr. Cook.

b^0 If $\frac{d^2\,t}{d\,x^2} = 0$ and $t = t_0$ for $x = 0$ (Free supported end)

and $\frac{d\,t}{d\,x} = 0$ and $t = t_2$ for $x = l$, ("Built-in" end)

$$t = \frac{\mathrm{R}^2\,\mathrm{P}}{\mathrm{E}\,t} - \left(\frac{\mathrm{R}^2\,\mathrm{P}}{\mathrm{E}\,t} - t_0\right)\Big(\cosh n\,x\cos n\,x - \mathrm{K}_0\sinh n\,x\cos n\,x + \mathrm{K}1_0\cosh n\,x\sin n\,x\Big) - \left(\frac{\mathrm{R}^2\,\mathrm{P}}{\mathrm{E}\,t} - t_2\right)\Big(+\,\mathrm{K}_2\sinh n\,x\cos n\,x - \mathrm{K}1_2\cosh n\,x\sin n\,x,\Big)$$

where

$$\mathrm{K}_0 = \cosh^2 n\,l\,/\,\mathrm{N},\ \mathrm{K}1_0 = \cos^2 n\,l\,/\,\mathrm{N}$$
$$\mathrm{K}_2 = (\cosh n\,l\cos n\,l + \sinh n\,l)\,/\,\mathrm{N}$$
$$\mathrm{K}1_2 = (\cosh n\,l\cos n\,l - \sinh n\,l\sin n\,l)\,/\,\mathrm{N}$$
$$\mathrm{N} = \cosh n\,l\sinh n\,l - \cos n\,l\sin n\,l.$$

In both cases the longitudinal stress P is put equal to zero (the longitudinal displacement being consequently different from zero) because the intention was to examine a certain rope-drum of a cable crane of $l = 2150$ by 1,200 mm. diam. It was found possible to diminish the thickness of the drum from 12 mm. to 8 mm. by inserting three angle steel frames of 50 mm. × 50 mm. × 7 mm. The maximum complex stress was allowed to be 1,250 kg./cm.² (7·9 tons per square inch), instead of about 900 kg./cm.² (5·7 tons per square inch) in the original construction. But the factor of safety against collapse, which was unduly low, had to be raised by 66 per cent. The weight of the new type of drum of "balanced safety" was 25·6 per cent. less than that of the original one. The problem will be still further investigated in another direction.

I am indebted to Dr. Ing. H. Techel of Kiel for bringing the "Article" to my notice of which otherwise I should have remained in ignorance. At present the "Technische Hochschule" cannot afford to subscribe to your excellent periodical of which I have been an ardent reader for 20 years.

Yours faithfully,
VON SANDEN.

Karlsruhe, Melanchthonstrasse 3.
November 30, 1923.

December 8.

BINARY-FLUID TURBINES.

TO THE EDITOR OF ENGINEERING.

Sir,—There may appear to be some justification for Mr. Satterly's remarks on my paper on "Binary-Fluid Turbines," but it remains a fact that the heat capacity of mercury is so small that, unless tabulated values are set down to five or six significant figures, they are of little or no use. The figure given in Table I for the vapour pressure of mercury at 32 deg. F. was not obtained from an original datum but calculated directly from equation (3), page 664, which is simply a conversion of Laby's formula (equation 2), taken from *The Phil. Mag.*, November, 1908. Mr. Satterly will see, if he refers to Laby's formula, that there are seven significant figures given throughout.

The vapour-pressure formula of Smith and Menzies is reputed to represent the experimental values with a surprising degree of accuracy. Within the range from 480 deg. F. to 815 deg. F. the pressure error does not exceed about 0·1 per cent., and is not 1 per cent., as stated by your correspondent.

With reference to the latent heats of vaporisation, the values of $\frac{d\,\mathrm{P}}{d\,\mathrm{T}}$ were not "got from the vapour-pressure curves," nor was there "an approximation to the value of $\frac{d\,\mathrm{P}}{d\,\mathrm{T}}$," as suggested by Mr. Satterly. The values of $\frac{d\,\mathrm{P}}{d\,\mathrm{T}}$ were obtained from the above-mentioned formulæ and expressed in terms of the constants β and γ, and are, therefore, as accurate as it is possible to make them. It is true that the "long complicated formulæ" giving the vapour pressure in terms of the temperature are largely empirical, but so are all those which are used in the compilation of steam tables in everyday use.

The formula given for the specific heat of the liquid represents Barnes' results accurately, and as I consider that Barnes' values are, for reasons given in the paper, more reliable than those of the other experimenters mentioned, I accepted them as a standard until such times as they may be replaced by newer and more accurate data.

In calculating the values of the various properties I early came to the conclusion that it was necessary to use seven-figure logarithms throughout. This may account for the "spurious accuracy" mentioned by your correspondent. Whilst there is some justification for Mr. Satterly's remarks, I plead that I was also justified, in the endeavour to make the best possible use of the available data, in adopting the methods I have done.

I am, yours very truly,
W. J. KEARTON.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—During the course of the meeting of the Institution on the 9th inst. the recently established medal of the Institution was presented to Dr. F. W. Lanchester in recognition of his contributions to scientific knowledge.

ENGINEERING SOCIETY, UNIVERSITY COLLEGE.—The annual dinner of the University College, London, Engineering Society, will be held in the college refectory on Friday, February 1, at 7.15 for 7.30 p.m. The chair will be taken by Professor E. G. Coker, F.R.S. Old students of the Faculty of Engineering who have not yet received notice are requested to communicate at once with the hon. secretary of the Engineering Society at the college. The dinner will be followed by a conversazione, when the new laboratories will be open for inspection.

THE ST. PAUL'S BRIDGE.—A Conference, presided over by Colonel Moore-Brabazon, the Parliamentary Secretary to the Ministry of Transport, was held at the Ministry on the 9th inst. to consider the St. Paul's Bridge scheme. The conference was attended by representatives of the Corporation of London, the London County Council, and the Boroughs of Southwark, Holborn and Finsbury. The attention of the conference was directed chiefly to the future road improvements which would be needed if full advantage of the new bridge were to be gained by traffic from the north and south of London. A general desire was expressed that the progress of the scheme should be expedited, having regard to the urgent need for an additional Thames bridge, and means were discussed for the allocation of the cost of the road improvements involved.

THE MARINE AND SMALL CRAFT EXHIBITION.—The experiment of holding an exhibition of boats, whether sail or motor propelled, and the equipment necessary for their successful running, proved so popular last year that it has been considered advisable to continue the effort. This year's exhibition will again be held in the Royal Agricultural Hall, Islington, and will run for a week, beginning on March 15. It is anticipated that there will be a greater display of marine engines and their associated gear than was the case last year, and during the course of the exhibition a series of lectures will be delivered and conferences will be held, on matters of interest to the users, designers and constructors of small craft and power units. Messrs. May and Pattisson, of 13, Victoria Street, Westminster, have the arrangements well in hand.

MATERIALS IN AIRCRAFT CONSTRUCTION.*

By LESLIE AITCHISON, D.MET., B.SC., F.I.C.

THE problems connected with the material used in the construction of aircraft are very numerous, and the time available in one lecture is far too short to consider them in any kind of detail. It seems to be more appropriate to approach the matter broadly and to consider some of the basic problems with a little thoroughness than to examine a number of details in a superficial manner. The main objection that can be urged against this method is that the conclusions reached are by no means confined in their application to aircraft materials, but apply almost equally to most of the arts in which the same or similar materials are employed. After all, the aeronautical engineer is mostly concerned to obtain the ideal sample of any chosen material. This is due firstly to the fact that he subjects the materials to a higher duty, and secondly (what is really only a corollary to the first cause) he leaves a much smaller margin to cover what is known sometimes as the factor of ignorance and sometimes as the factor of unreliability, but what is (however named) the factor which represents the degree to which the material actually differs from the ideal sample of the material. The smallness of this allowance—the margin of manufacturing error—which is the distinguishing mark of aeronautical construction (as viewed by the metallurgist) is really a most important matter. The problem of aeronautical materials becomes in fact very largely the problem of how to minimise the dangers that arise from the narrowness of the margin permitted between the "ideal" and the average "real."

It must be said at once that only the metallic materials of aircraft construction are contemplated herein. These materials mainly comprise the following items :—

(*a*) Mild steel in the sheet form.
(*b*) Medium carbon steel (as cold drawn or hot rolled in bars and as drop forgings).
(*c*) Strip steel of varying maximum strengths.
(*d*) Medium high tensile steel as sheet and bar.
(*e*) High tensile cold-worked bars, rods and wires.
(*f*) Duralumin as sheet, strip and forgings.
(*g*) Aluminium as sheet and strip.
(*h*) Steel, aluminium and Duralumin tubes of various maximum stresses.
(*i*) Light alloy castings.

How can all these materials be considered together, *i.e.*, as mere examples of one and the same problem? The only way is to find out what are the most common properties that are expected to be present in one and all. These would appear to be only strength and lightness, or what may be called generally specific strength, *i.e.*, the strength per unit mass. The plain consideration therefore becomes that of the properties that really constitute the strength of the materials as they are used. The best way in which the strength can be considered is to examine those properties that contribute towards strength and then to see in what ways and to what extent these properties are affected by the other qualities of the materials —as manufactured, and as treated by the aero constructor. In the course of this examination it may well be found that the apparent paradox that "the stronger the material the weaker the part" is largely true.

Considering the metallic materials quite generally, it is fairly evident that the aero constructor views strength in various ways, and in fact utilises various mechanical properties of metals as criteria of the strength of different parts. At different times he appears to require the maximum stress, the elastic limit, the proof stress, the yield point, or the fatigue strength of the metal. With all these properties he yet calls for an accompaniment of a high ductility and as great a toughness as possible. The reason for these last requirements will be considered later. At the same time the constructor is interested in the value of the Young's Modulus of the materials.

It may be of some advantage to devote a little space to these different properties in turn. The first to call for attention is the maximum stress. The values generally found in typical samples of the materials given above, supplied in accordance with B.E.S.A. specifications, are given in Table I. Side by side are quoted the strength density ratios of the materials, these of necessity providing a sounder basis of comparison for many purposes than the strength/area ratios usually quoted.

TABLE I.—*Strength/Density Ratios of Various Metals.*

Material.	Max. stress tons/sq. in.	Max. stress/ density.
Mild steel sheet	26	3·30
Medium carbon steel	36	4·60
Cold-drawn steel	36	4·60
Medium tensile steel strip	52	6·62
High tensile steel strip	76	9·70
Medium tensile steel bar	55	7·0
High tensile cold-worked steel ..	78	10·0
Duralumin	27	9·6
Aluminium	10	3·67
Soft aluminium	6	2·22
Light alloy castings	10	3·40

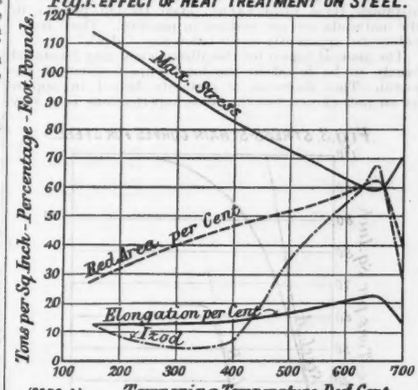
The figures in the table call for little comment, showing as they do a range of maximum stress from 6 to 78 tons and a strength/density ratio between 2·2 and 10·0. It may be asked quite legitimately why the maximum stresses for each material are limited in the way indicated by these figures. This question very often receives its best answer on practical grounds, though it must be admitted that, in some instances, the practical reasons are prejudices sanctified by prolonged observance and that they cease to be good reasons when examined impartially.

Even so, there is some quite reasonable ground for the particular values of maximum stress that are quoted, and in quite general terms it may be said that the values chosen are those that with a given metal are accompanied by the most satisfactory ductility and toughness. This statement applies perhaps more particularly to steels than to the other materials, but is true of all metals in a greater or less degree. To indicate this briefly the test records given in Table II and Fig. 1 for a typical steel may be referred to. These tests clearly show that at a certain maximum stress, the ductility and toughness

TABLE II.—*Properties of Hardened Tempered Steels.*

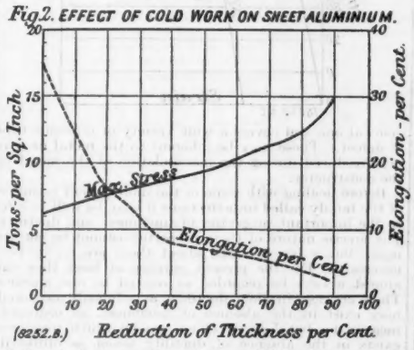
Hardening Temp.	Tempering Temp.	Max. Stress.	Elongation.	Red. Area.	Impact.
deg. C.	deg. C.	tons/sq.in.	per cent.	per cent.	foot lb.
830	—	114	13	28	12
830	300	96	13	40	5
830	400	83	14	47	7
830	500	73	17	52	35
830	600	63	21	59	55
830	650	59	23	63	67
830	700	71	13	40	29

Fig. 1. EFFECT OF HEAT TREATMENT ON STEEL.



(8252.A)

Fig. 2. EFFECT OF COLD WORK ON SHEET ALUMINIUM.



(8252.B)

of the steel are at a maximum. With this particular steel, then, the most suitable maximum stress is clearly 59 tons/sq. in. The same kind of information could be shown for other steels, which leads to the definite conclusion that for any particular steel the best condition is produced by such and such a heat treatment, which in turn fairly definitely fixes the maximum stress (and incidentally the concomitant ductility and toughness). Conversely it can be said that for any particular maximum stress there is a particular steel, heat treated in a particular way, that gives this maximum stress most suitably. The variation in the other properties of a number of steels, all heat treated to give the same maximum stress, are shown in Table III, where the superiority of one particular steel as regards ductility and toughness is manifest. It is a sound rule to work upon that an alteration in maximum stress is better obtained by the use of a different material than by an alteration in the treatment of the same material, for the same material cannot very well have two best conditions.

The same considerations apply to the light alloys, however they are hardened. At a certain value of maximum stress the best values of ductility are obtained by using a certain material in a certain way. The range of combinations is not so wide as with steel, but a fairly large variation may be induced by differences in the amount of working. This process should be very carefully and strictly controlled, as otherwise maximum stress will be obtained at the expense of other equally valuable properties.

Whilst dealing with maximum stress it may be pointed out briefly that hardened and tempered steels are the most suitable to give useful values of this property. Higher values are usually produced by hardening either by quenching or by cold working, and both these processes reduce the ductility and toughness. Consequently the brittleness of quenched steel should be reduced by tempering—at the highest convenient temperature—whilst the brittleness of the worked materials should be reduced by limiting the amount of work-hardening as much as possible. The effect of varying amounts of cold work upon both the strength and the ductility of a typical material can be seen in the values shown in Table IV and the curves in Fig. 2.

TABLE III.—*Effect of Heat Treatment of Different Steels.*

——	Max. stress.	El'gation.	Impact.
	tons sq. in.	per cent.	foot lb.
Air-hardened 820 deg. C., tempered 500 deg. C. ..	76	16	32
Air-hardened 820 deg. C., not tempered	73	14	7
Oil-hardened 850 deg. C., tempered 400 deg. C. ..	77	17	14
Water-hardened 850 deg. C., tempered 400 deg. C. ..	75	14	11
Water-hardened 870 deg. C., not tempered	77	10	3
Water-hardened 860 deg. C., tempered 500 deg. C. ..	74	16	10

TABLE IV.—*Effect of Cold Work on Sheet Aluminium.*

Reduction of Thickness	Max. stress.	Elongation.
per cent.	tons sq. in.	per cent.
—	6·2	35
10	6·9	25
20	7·5	16
30	8·2	12
40	8·9	8
50	9·6	7
60	10·5	6
70	11·5	5
80	12·4	4
90	15·0	2

The elastic limit of metals is a very variable proportion of the maximum stress. For the typical materials quoted above the values of this property are shown in Table V, together with the ratio between the elastic limit and the density, and also that between the elastic limit and the maximum stress. The variations are obvious both in the absolute values and the ratios.

TABLE V.—*Elastic Limit of Various Metals.*

Material.	Elastic limit.	Elastic limit. Max. Stress	Elastic limit. Density.
	tons sq. in.		
Mild steel sheet	13	0·50	1·65
Medium carbon steel ..	18	0·50	2·30
Cold-drawn steel	27	0·75	3·35
Medium tensile steel strip ..	35	0·67	4·45
High tensile steel strip ..	50	0·66	6·4
Medium tensile steel bar ..	35	0·64	4·45
High tensile cold-worked steel	25	0·32	3·20
Duralumin	15	0·58	5·30
Aluminium	7·5	0·75	2·77
Soft aluminium	2·5	0·42	0·93
Light alloy castings	4·0	0·40	1·38

It is to be remembered that hardening a metal, either by quenching or the application of cold work, generally reduces the ratio between the elastic limit and the maximum stress, and that this ratio can be recovered and often actually increased by subsequent reheating. All steels that have been hardened should therefore be reheated to temperatures of at least 350 deg. C. The quenched steels should be tempered at higher temperatures than this for other reasons (ductility and toughness), but if the work-hardened steels are heated beyond 450 deg. C. they lose the strength imparted by cold working.

After quenching and tempering, or work hardening and blueing, the ratio of elastic limit to maximum stress of all metals is markedly higher than in the same metals when normalised. The same thing applies to the light alloys when cold worked and reheated to relatively low temperatures. This can be appreciated from a reference to Table VI.

TABLE VI.—*Effect of Heat Treatment on Elastic Limit.*

Condition.	Elastic Limit.	Elastic Limit. Max. Stress.
	tons sq. in.	
Normalised	22	0·55
Worked not blued	24	0·39
Worked blued 100 deg. C... ..	32	0·55
,, ,, 200 deg. C... ..	38	0·67
,, ,, 300 deg. C... ..	45	0·75
,, ,, 400 deg. C... ..	42	0·72
,, ,, 500 deg. C... ..	37	0·71
,, ,, 600 deg. C... ..	28	0·70

The proof stress of metals is not without its controversial aspect. In these present remarks it may be as well, therefore, to say that the property is taken to be the stress that produces 0·1 per cent. strain greater than the elastic strain produced by the same stress, assuming that E is the same at this stress as at stresses inferior to the elastic limit. The variations in the value

* Paper read before the Royal Aeronautical Society on Thursday, January 10, 1924.

of this property can be seen from Table VII, in which are shown not only the proof stress but the proof stress/density ratios and the proof/stress maximum stress ratios of various typical metals.

TABLE VII.—*Proof Stress of Various Metals.*

Material.	Proof stress	Proof stress / Max. stress	Proof stress / Density.
	tons sq. in.		
Mild steel sheet	16	0·62	2·05
Medium carbon steel ..	22	0·62	2·80
Cold-drawn steel	30	0·83	3·82
Medium tensile steel strip ..	42	0·80	5·35
High tensile steel strip ..	57	0·76	7·3
Medium tensile steel bar ..	40	0·73	5·1
High tensile cold-worked steel	40	0·52	5·1
Duralumin	16·5	0·62	5·9
Aluminium	8	0·80	2·95
Soft aluminium	3	0·50	1·11
Light alloy castings	5	0·50	1·73

Substantially it may be said that the rules that apply to the elastic limit apply equally to the proof stress, though perhaps not in quite the same degree. Nevertheless, it is of importance to appreciate that the reheating of hardened materials is necessary in order to induce the highest ratio of proof stress to maximum stress.

A further point of the same kind is to be noticed in regard to the ways in which the other properties may vary in two materials having the same proof stress. In Table VIII are shown the complete tensile properties of two steels having substantially the same proof stress. These are decidedly different. The difference is just as great and perhaps more obvious in the stress/strain curves of the two materials as set out in Fig. 3.

TABLE VIII.—*Tensile Properties of Steels.*

—	Steel A. Quenched and Tempered.	Steel B. Worked and Blued.
Proof stress tons/sq. in. ..	64·5	62·9
Elastic limit tons/sq. in. ..	24·1	41·9
Max. stress tons/sq. in. ..	110·5	63·8
Elongation per cent. ..	12·0	11·5
Red. of area per cent. ..	28·0	27·3

If they show nothing else, the values in Table VIII and the curves in Fig. 3 indicate plainly that the quotation of the proof stress is by no means an exhaustive definition or a precise statement of the mechanical properties of a metal.

So much has already been said about the fatigue strength of metals, and so much more is likely to be said before the process of fatigue is wholly defined and understood, that no useful purpose would be served by discussing the property as a property. It must be sufficient to quote the actual values that have been obtained upon various metals.

These values all represent one set of conditions, *i.e.*, equal plus and minus stresses, and a representative set of such values are given in Table IX.

TABLE IX.—*Fatigue Ranges of Various Metals.*

Material.	Fatigue Range. Tons/sq. in.	Fatigue Range, Max. stress × 2.	Fatigue Range, Density
High-tensile alloy steel	±41	0·50	10·4
Medium tensile alloy steel	±28	0·50	7·1
Medium carbon steel	±17	0·45	4·3
Cold-worked steel	±16	0·42	4·1
Mild steel	±12·4	0·42	3·1
Duralumin	±10·5	0·41	7·44
Light alloy castings	± 3·0	0·30	1·94

In the same table are given the ratios of fatigue range to the maximum stress and also the ratios of the fatigue range to the density of the various metals referred to.

One of the singular things about the fatigue strength of metals is their almost complete independence of all the other mechanical properties of the materials. It seems to be established fairly definitely that the highest ratio of fatigue range to maximum stress is found in the metals having the lowest maximum stress. It is certain that this ratio is lower in hardened metals than in the same metals after the hardness is reduced. (This really refers chiefly to steel and iron. Soft iron gives the highest ratio in this class of metal. The variations with other metals are not so easy to demonstrate.)

Time is not available for an investigation of the way in which the fatigue range of a metal is affected by variations in the relative magnitudes of the component stresses of the range, but it is not wise to omit all reference to the fact that the fatigue range of a metal (even under equal plus and minus stresses) is affected greatly by its condition. Cast metal gives a much lower value than the same metal when forged. Also a steel that is tested so that the fatigue stresses are applied parallel to the grain of the metal has a higher fatigue range than the same metal tested so that the stresses are imposed at right angles to the fibres.

The very notable variations in the actual values of the fatigue ranges of material under different conditions makes it very necessary that a conservative estimate should be made of the resistance of any metal to fatigue stresses. They also indicate the need of intense caution in accepting any particular margin of safety that is based upon an assumed value of the fatigue range, which may be correct for one set of conditions.

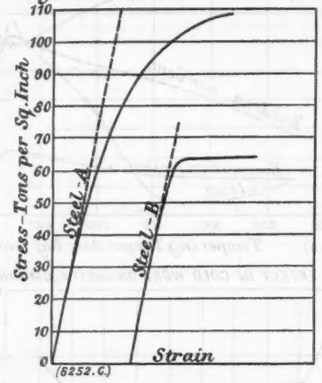
Without claiming too much accuracy for the generalisation, it may be suggested that in the steels used in aircraft it would be reasonable to take ±40 per cent. of the maximum stress as representative of the fatigue range in "longitudinal" specimens and about ±30 per cent. in "transverse" specimens. For light alloys both of these values ought to be reduced by about one-third. Doubtless there are many, if not a majority of instances in which it is scarcely possible to diagnose the condition of a particular part and to say that the stresses (in so far as they are fatigue) are applied in the longitudinal or the transverse direction exclusively. In most instances it would appear wisest, therefore, to assume that the transverse conditions hold, and to calculate the factors of strength accordingly.

The values given above are, of course, those obtained in tension and compression. The torsion values are less than the tension, but generally appear to be less by a definite proportion, being usually round about 60 per cent. of the tension values in so far as they have been determined.

By means of such figures and considerations as those given above, it seems likely that the strength values of the various aircraft materials may be regarded as well covered. The values given, however, are more or less the "ideal" values, and the "real" ones may be quite appreciably different from the "ideal." What amounts to much the same thing in the end, though it is scarcely the same thing in appearance, is that in very many instances these ideal values, even though present in the materials, are not realised in practice. The "real" values are apparently much below the "ideal."

The general reason for this discrepancy may be stated briefly to be found in the local imperfections of the metal. This diagnosis is certainly bound to appear as an anti-climax, but the term imperfections is a very

Fig. 3. STRESS-STRAIN CURVES FOR STEEL.



general one and covers a wide variety of different type of defect. These may be inherent to the metal or may be introduced during the manipulation of the metal by the constructor.

Before dealing with some of the more potent members of the family called imperfections it may be well to refer to the important properties of toughness and ductility. The precise nature of those properties cannot be entered upon, but a few remarks about them are really very necessary. For the present purpose at least they can almost always be regarded as related to one another. There are cases in which ductility, as ordinarily measured, may exist in the absence of toughness, as ordinarily measured; but I know of no case in which toughness exists in the absence of ductility (even as ordinarily measured). Looking at the problem in another way, it may well be thought that toughness is nothing but an expression of effective ductility. Without ductility a metal cannot be tough, and if the material has ductility under certain conditions, but is so lacking in toughness that it cannot make use of its ductility, it might as well be non-ductile. Supremely, therefore, a metal requires toughness, as this property brings with it ductility, and what is more, the power to make effective use of its ductility.

Toughness and ductility as ordinarily expressed in metals are generally inversely proportional to the strength values as ordinarily stated. Harden a metal, either by working or by quenching, and down go its toughness and ductility. Even by taking a variety of compositions of steel—suited to give a variety of strengths—the same general results are obtained, namely, that the higher the strength the lower the ductility and the toughness.

It is also sometimes possible to increase by heat treatment the ductility and toughness of a metal that is fully hardened in such a way that its maximum stress is not materially decreased. Examples of this are shown in Table X.

TABLE X.—*Effect of Heat Treatment on Ductility and Toughness.*

Condition.	Max. stress	Elongation	Red. of area
	tons/sq. in.	per cent.	per cent.
Work-hardened	72·0	5	18
Work-hardened and blued	72·9	10	37
Quenched	115·0	4	13
Quenched and tempered	113·0	10	31

The final remark that should be made regarding toughness and ductility is that both are affected materially by the condition of the metal. Cast metals have lower ductility and toughness than the same metals when forged, and the values of these properties "longitudinally" are markedly higher than the values "transversely," although the strength factors remain unaltered. This point is adequately illustrated by the figures given in Table XI taken from one and the same metal.

TABLE XI.—*Properties of Metal in Cast and Forged Conditions.*

	As cast.	Forged (longitudinal).	Forged (transverse).
Elastic limit tons/sq. in.	16·4	20·1	18·9
Max. stress tons/sq. in.	38·3	36·0	36·0
Elongation per cent. ..	19·7	33·1	23·5
Red. area per cent. ..	25·8	58·7	43·5
Impact foot lb. ..	16·0	86·0	29·0

(It is not without significance, I think, that the fatigue range is affected in much the same general way as the ductility and toughness, although the other strength properties remain unaffected.)

It seems reasonable, then, to draw the conclusion that ductility and toughness are increased by processes that soften a metal and reduced by processes having the reverse effect. Also they are improved by homogeneity (in the macroscopic sense), and by the greatest freedom from the disturbing effects of fibres and the like. These conclusions have been drawn here because they must be applied to many examples of the disparity between "ideal" and "real" strength values.

Some of the "imperfections" can now be examined. One of the most potent is the group including slag, non-metallic inclusions, and the like. All these constituents of metals have their origin in the metal-manufacturing process and grossly affect the ductility of the metal, particularly when the ductility is called upon to operate in directions perpendicular to the slag streaks. In this direction the ductility is so much reduced by inclusions that a metal can rarely flow as much as is expected of it. Failure to flow is generally but another way of saying that the metal breaks—a thing that occurs very frequently in the forming of spar sections from metal strip.

Roaks and contraction cavities that are rolled or drawn out to notable lengths are also metallurgical in their origin, but should really be classed with such imperfections as cracks, splits and jagged edges in holes, rough machine marks, tears made during punching and riveting, and such like defects. It has been well established that the presence in a metal of any such defects affects very markedly the distribution of stresses within the metal. The general net effect is an adverse one and operates by markedly increasing the stress value in the part at the position of smallest radius in the imperfections mentioned. A roak or a contraction cavity can scarcely be distinguished from a ragged tooling mark or a tear around the periphery of a rivet hole, except that the profile is generally rather smoother and the liability to stress concentration rather less. It must be very evident, therefore, that all in this class of imperfection are likely to be specifically harmful and to bring down the real strength of a part so materially as to constitute a notable menace to the safety of a machine for which the calculations have been made without taking such possibilities into account.

This is the point at which the toughness and ductility of the metal definitely may come into operation. When a stress is applied to a part, and by reason of notches or the like, it is unevenly distributed so that it has its maximum intensity at certain positions, the excess of the actual stress at these positions over the assumed mean stress in the part may be sufficient to cause the actual stress to exceed the elastic limit of the metal materially. Granted that the metal has sufficient effective ductility, it will flow at the position of highest stress, and will flow in such a way as to reduce the intensity of the stress at the considered point. In order to reduce the stress to a value lower than the elastic limit of the metal, quite a considerable flow may have to occur within the small element of metal that is actually subject to the abnormally high stress. This amount of flow can only occur in metals that possess adequate ductility and toughness. Unless the requisite flow occurs, fracture is almost sure to ensue, and, in fact, to intervene before the stress is reduced to a harmless value.

The importance of the presence of the necessary ductility is manifest. Consider two pieces of metal—one having half the ductility of the other. In many instances this might well mean the less ductile metal having approximately twice the strength of the other. In the ordinary way the mean stress on the parts might be expected to be in general proportion to the maximum stress. The concentrating effects of the defect take no account of actual maximum stress, so that the local stress in one will be twice that in the other. In order, therefore, for the reduction of the magnified stress to come about by the flow of the metal, the same amount of plastic distortion must occur in both metals. With the more ductile metal the flow may occur and a satisfactory readjustment be brought about. With the less ductile metal this does not occur because the requisite ductility is not available, and before safety is reached the fracture of the metal occurs. This is a parallel case to that of Mr. Micawber's famous balance sheet, but is also a very good example of the paradox that "the stronger the metal the weaker the part."

The methods by which an adequate ductility can be ensured have been indicated already and need not be repeated. The main things to remember are that reheating after hardening is of great value in raising the ductility and toughness of a metal, and that for any given maximum stress (proof stress or the like) a certain

combination of chemical composition and heat treatment brings about the highest accompanying ductility and toughness.

Besides the causes already mentioned that reduce the strength of a part, one other, namely, corrosion, must be considered. This process has two effects. Firstly, it may generally reduce the strength of a part, but this effect is relatively unimportant. Secondly, it may reduce the strength of a part very locally by the formation of a corrosion pit or a corrosion notch. Such defects will have all the bad effects of the other kinds of notch and at the same time may be more insidious, as they are unsuspected because of their non-existence at the time that the part was made and inspected. It is clearly therefore, amongst the less ductile metals that immunity from corrosion is likely to be of the greatest importance and value.

A further type of imperfection is one that is very frequently overlooked. This is the type known as internal strain or internal stress. Of this type of trouble a good deal has been written at one time and another, and those interested can consult the original writings. The presence of stresses within many parts bearing no external load is very well proved, and the magnitude of the stresses can be gauged from the fact that they are frequently sufficient to fracture a part that is standing quite idle. Usually, if not inevitably, such fracture occurs only in those parts in which there is a notch or corner that may act as a localiser for the stresses, but even so the average magnitude of the internal stress that will cause the spontaneous fracture of a die block weighing half a ton is by no means small.

The most prolific source of internal stresses is hardening—either by quenching or by working—and the former is usually the more potent. In most instances the immediate cause is merely the uneven rates of cooling of different portions of the same article. This may sometimes occur even where there is no deliberate intention of hardening, a good example of such being in welding, whether of plain carbon steels or alloy steels. The only cure for the welding trouble is a reheating of the whole article followed by regular and even cooling. For the internal stresses due to hardening the best cure is a tempering treatment at a fairly high temperature. This operates in a dual way: firstly, by reducing the differences of volume that cause the stresses, and, secondly, by increasing the ductility and so making the flow of the metal more probable than its fracture.

The need of such a treatment is very obvious. If a part is already under stress, the further stress that can be put upon it without fracture can (in certain directions at least) hardly be greater than the difference between the existing stress and the maximum stress of the metal. The mere existence of the internal stress consequently very materially reduces the real strength of the part below that indicated by the ideal strength that is expected of the metal that composes it. As the incidence of high internal stresses is most frequent in metals of fairly high maximum strength, the intrinsic weakness of many parts made of "strong" metals is once again manifested.

The points that have been raised in the course of the above remarks have been intended to illustrate the ways in which the disparity between ideal and real values may arise. As stated at the beginning, these causes are not entirely unique to aircraft material, but become of greatest importance in this craft because of the smaller margin allowed for such like defects. Granted the existence of the defects or imperfections, the question arises at once as to whether the margin provided is sufficient to be safe. No simple answer can be given to this question. For some materials and under certain conditions the answer would be easily the opposite of that for other metals in other conditions. What is certain is that in general it is none too great, taking all in all.

A second question naturally arises when it is asked how may the margin be made most effective—or (what amounts to much the same thing) how may the defects be rendered most ineffective. Again, there is no golden gospel that preaches salvation for all cases, but certain beneficial lines of action have been indicated earlier. In the first place, it is a very good rule to decide that a material shall be used only in that state in which it possesses the most satisfactory combination of maximum stress and ductility. There are definite limits to the possibilities in respect of both types of property and these should be carefully respected. High maximum stress in the absence of adequate ductility does not constitute strength but weakness. Hardened metals—whether hardened by working as in aluminium or by quenching as in alloy steels—are not ductile or tough. The values of both properties can, however, be markedly improved by reheating the metal to suitable temperatures. The most suitable temperature depends upon the nature of the metal, the type of hardening, the degree of hardening, and the purpose to which the part is to be put, but it is a good and sound rule to make the reheating temperature as high as possible. Besides its direct effect upon the toughness and ductility of a metal, this process also has decidedly beneficial effects upon the elastic limit, proof stress, fatigue range and freedom from internal stress. For the purely metallurgical defects, such as inclusions, nothing need be said here as the aircraft constructor cannot do anything practical with them that has any remedial effect.

THE SHIPMENT OF LOCOMOTIVES TO INDIA: ERRATUM.—Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, advise us that in connection with the information on which our account on page 802 of our issue of December 28 last was based of the shipment made by them of locomotives to India, in the ss. Belgot, the month October should have read November.

THE ECONOMIC STATUS OF THE DIESEL ENGINE.*

By L. H. MORRISON, New York, N.Y.

PROBABLY never before in history has the world been so thoroughly convinced of the necessity of decreasing production costs. Since power is one of the important items in the manufacture of practically all articles of commerce, the endeavour has been to reduce the expenses of generating this power. The consequence has been that central stations have employed larger and more complex equipment until the efficiency of 18 per cent. to 20 per cent. now obtained in some plants represents the limit of possibilities unless excessively high pressures are called into use. The very complexity of the equipment has caused a decrease in reliability, and a greater investment in reserve equipment is required to insure continuity of service. It is unfortunate that designers and executives of the larger public-service corporations have failed to include the Diesel engine in their investigations on the ways and means to decrease the cost of electric energy, for the fact is that the efficiency of the steam plant has reached its peak and the oil engine is now the cheaper form of power.

The Question of Power Limitations.—The oil engine has heretofore been built in comparatively small powers. This undoubtedly is the reason that no Diesel-engine central station of even moderate capacity is in existence in this country. Many units of 3,000 h.p. are in stationary service in Europe and have been built in the United States for marine service, such as the Sun-Doxford 3,000-h.p. unit shown in Figs. 1 and 2, page 92; there is no constructional reason why units of 6,000 h.p. cannot be built by a number of American manufacturers. That units of even 10,000 h.p. are feasible is proven by the 16,000 h.p. two-cycle double-acting Diesels built by Krupp and by M. A. N. for a German warship. One of these engines (Fig. 3†) was destroyed by a fire arising from external causes, while the second unit was broken up by orders of the Allied Commission. The results obtained during the tests on one of these units fully justify the assumption that units of this power are feasible and only await the commercial demand.

Some have pointed out that the Diesel cannot be used in present-day stations of 200,000 kw. to 300,000 kw. capacity, since even were the units of 10,000 kw. capacity, 20 to 30 would be required. If such large stations were necessary the argument would be on solid grounds, but the only excuse for the existence of large plants is that there is ordinarily a gain in efficiency with an increase in individual prime mover capacity. For this reason the generating equipment supplying a large system is centred in one or possibly two plants, even though a distribution loss of as high as 20 per cent. to 30 per cent. results. Taking a 200,000-kw. system as an example, it would be possible by locating 10 plants in strategic load centres largely to eliminate the distribution loss. This arrangement is impossible with steam equipment since the smaller plants would be inefficient. With Diesels, on the other hand, such an arrangement would not increase the investment above the present costs of modern superpower steam stations, and the generating efficiency would still be higher than that of the steam station. This is due to the fact that the efficiencies of small Diesels are almost as high as those of large units, the variation being about 10 per cent. Such an arrangement of decentralisation of generating equipment would increase the reliability of service and largely eliminate the distribution losses.

Economic Life of the Diesel Engine.—The cost of power generating is by no means the mere operating charge but includes overhead charges as well. In pre-war days the highly efficient steam plant required a capital investment much under that of a Diesel plant, and the higher overhead of the latter often more than offset its lower operating costs. Now the costs of steam and oil engine plants are on a parity; if anything, the Diesel will cost less. In Fig. 4, page 93, are shown the total investment costs per kilowatt of oil engine plants of various capacities. It will be noted that at 2,000 kw. the Diesel plant will cost 90 dols. per kilowatt, including all equipment investment other than the cost of the ground space. This expenditure compares favourably with the cost of steam turbine plants of 100,000 kw. capacity. It is reasonable to assume that a 20,000-kw. Diesel plant consisting of, say, six 4,000-kw. units, will cost somewhat under this amount. Apparently the two types of plants are on more or less of a parity as regards first costs, and the interest items in the overheads will not be far dissimilar.

The life of the equipment must not be lost sight of, for depreciation and obsolescence are of vital importance in determining overhead. What the actual life of a steam turbine or reciprocating engine might be is hard to determine, for there are reciprocating engines still in service after fifty years of usefulness. There is no reason to assume that a steam turbine should have a shorter physical life. Engineers, on the other hand, not being conversant with the history of the oil engine, are prone to assume the Diesel to have but a short life, the guess varying from fifteen years down to even ten years. Such estimates are worthless and can only be attributed to undue cautiousness. It is impossible to state with any degree of accuracy how long an oil engine will stay in operating condition, for it must be realised that the Diesel had its commercial birth about 1900. In this country, one engine, which is still in existence, was built in 1897, but it was not until 1903 that manufacturing on a commercial basis began. Records of the Diesel engines built by the original American company and its successors show the following terms of service:

Number of engines ...	27	47	76	125	130	137
Years operated (or longer)	20	19	18	17	16	15

Considering engines of over 100 h.p., of the total number sold by this company in the past twenty years, 96·7 per cent. are in service; 2·0 per cent. are for resale; of 0·66 per cent. there is no record; and 0·64 per cent. have been scrapped.

The history of the engines sold by other Diesel builders since 1912 is equally as conclusive that with ordinary repairs an engine should last at least twenty-five years. That this is reasonable will appear upon consideration of the engine's construction. The parts that wear out are cylinder liners, pistons, bearings, valves, and other small parts. The other parts of the engine, representing at least 75 per cent. of its cost, remain intact regardless of the length of service. The author is of the opinion—and he is supported in this by others—that a maintenance charge of 2 per cent. will cover all the running repairs and the general overhauling required. During the early period of the engine's life this percentage will be far more than is needed, and the excess can be set aside to be used at times when a general overhauling is needed. While a physical life of twenty-five years is assumed, one would no doubt be safe in counting on a much longer term.

Those who are closely associated with power-plant design often contend that the useful life of a machine is by no means the physical life. By reason of the invention or creation of more efficient units the central station seldom permits its equipment to wear out, but after a few years' service discards the turbine or boiler in favour of units of newer and more efficient design. No doubt this is justifiable, but in the case of the Diesel it is unnecessary. Strange as it may seem, the increase in the efficiency of the Diesel engine since its inception has been but slight. As example, in 1904 a 225-h.p. Diesel upon test gave the following efficiencies:

Load.	Duration of test. hours.	Fuel, lb. per b.h.p.	Brake efficiency. per cent.
Half ...	2	0·558	23·3
Three-quarters	2	0·443	28·7
Full ...	2	0·44	30·0
1·1	2	0·44	30·0

A modern 750-h.p. Diesel on test gave results as follows:

Load.	Fuel. lb. per h.p.	Brake efficiency. per cent.
Half	0·48	28·5
Three-quarter	0·43	31·8
Full	0·395	34·5

The 12,000-h.p. Diesel heretofore referred to gave the following results on test:

Load.	Fuel. lb. per b.h.p.	Brake efficiency. per cent.
Quarter	0·57	24
Half	0·48	28·5
Full	0·44	31

The difference in the efficiency between an obsolete type and a modern Diesel is then approximately 10 per cent. This is in striking contrast with the steam plant which, dependent upon its size, equipment, and management, may have an efficiency of anywhere from 2 per cent. to 18 per cent., the latter being about the maximum attainable, even though excessively high pressures and temperatures are adopted in the future. The conclusion to be drawn from these tests coupled with the known possibilities of the steam plant of the future is that the efficiency of the earliest Diesel is 50 per cent. higher than that of the best steam practice and that little improvement in the Diesel efficiency is possible. The test shown below serves as an additional support to this argument. It will be noticed that in 1910, the date of manufacture, the 225-h.p. unit C delivered a kilowatt at the expense of 0·69 lb. of fuel. In 1921, after being overhauled, only 0·74 lb. was required, the difference probably being due to variation in the oils used and in the greater accuracy of the longer test. The 1921 result compares very favourably with the results for the two units A and B which were more modern in design and of twice the capacity.

Engine	A	B	C	
Horse-power	500	500	225	
Year manufactured ..	1916	1917	1910	
Year tested	1921	1921	1921	1910
Oil consumed, lb. ..	20,556	21,071	11,970	—
Kilowatt-hour output ..	30,970	29,050	16,090	—
Length of test, hours ..	100	100	100	1
Load factor, per cent. ..	86	90	90	100
Pounds fuel per kilowatt-hour	0·66	0·72	0·74	0·69
Kilowatt-hours per barrel of fuel	476	436	425	455
B.Th.U. per kilowatt-hour	12,478	13,636	13,994	13,045
Fuel cost per kilowatt-hour (3·23 dols. per barrel, in mills) ..	6·60	7·41	7·10	—

While the necessity of an obsolescence charge in a steam plant is not denied, examination of the history of the Diesel engine indicates that for it such a charge is unnecessary and that the engine's useful life is its physical existence, which is, under normal conditions, at least twenty-five years.

With equal investment costs the longer economic life of the Diesel should cause the overhead chargeable to such a plant to be much below the overhead of a steam plant, where an obsolescence charge of at least 5 per cent. must be included. If, then, a steam plant is to be

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* Paper read at the American Society of Mechanical Engineers' Annual Meeting, New York, December 3 to 6, 1923.

† We have not reproduced the photograph (Fig. 3).

3,000-B.H.-P. SUN-DOXFORD DIESEL ENGINE.

Fig. 1.

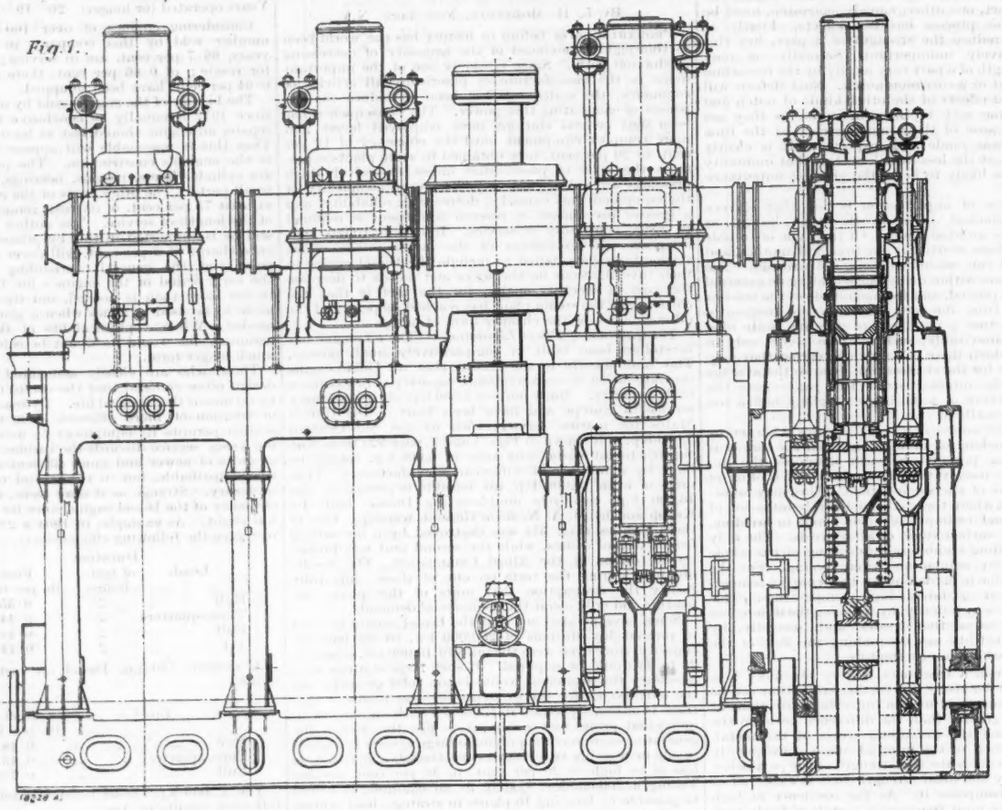
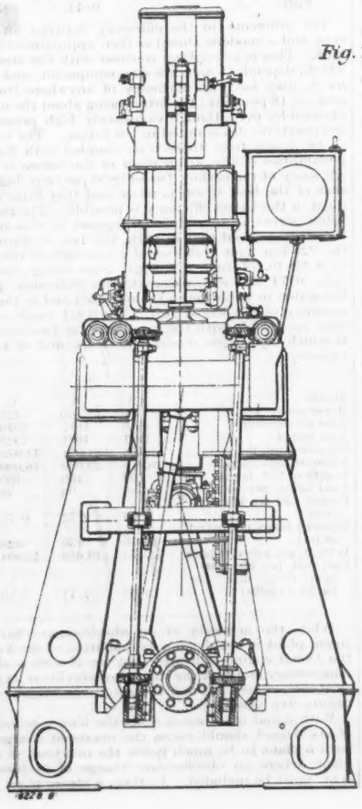
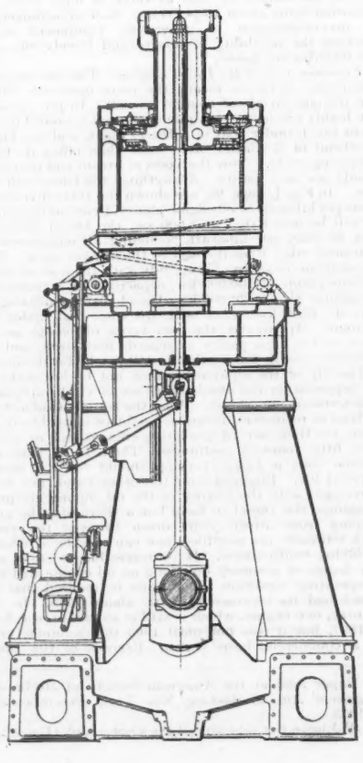


Fig. 2.

ELEVATION LOOKING ON FORWARD END



SECTION THROUGH SCAVENGE PUMP



SECTION THROUGH WORKING CYLINDER

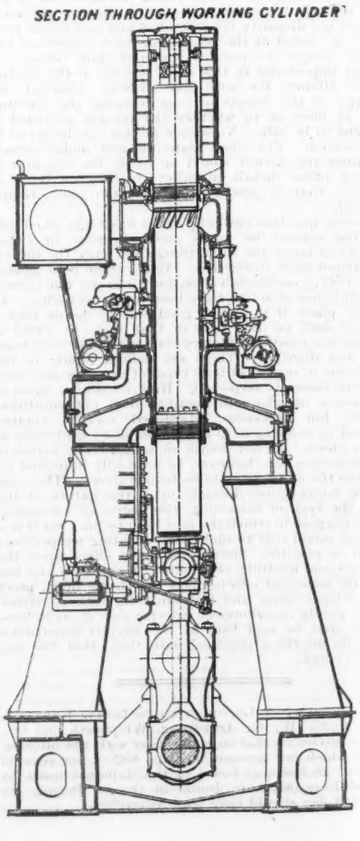


TABLE I.—OPERATING ECONOMY AND PRODUCTION EXPENSES OF COAL-BURNING GENERATING STATIONS (10,000-122,000 KW.)

Station.	Installed Generator Rating. Kw.	Annual Plant Factor. Per Cent.	Annual Output. Kw.-Hr.	Peak Load. Kw.	Annual Fuel Consumption. Short Tons.	Average B.Th.U. Per Lb.	Average Ash Per Cent.	Price of Fuel Delivered. Per Ton. Dol.	Pounds Fuel per Kw.-Hr.	B.Th.U. per Kw.-Hr.	Unit Production Expenses (Cents per Kw.-Hr. Delivered from Switchboard). Operating Expense. Fuel.	Wages and Superintendence.	Water, Lubrication and Supplies.	Total.	Maintenance Expense. Building and Structures.	Boiler Plant.	Prime Movers and Auxiliaries.	Generators & Electrical Equipment.	Miscellaneous.	Total.	Grand Total.	Energy Consumed in Station. Included.	Boiler Equipment. No.	H.p.	Generator Equipment. No.	Kw.
289	122,000	18·6	198,786,421	62,000	223,177	11,019	14·4	3·96	2·24	22,670	0·442	0·102	0·056	0·601	0·004	0·043	0·010	0·003	0·001	0·060	0·661	..	32—	518	3—	20,000
																							24—	558	4—	12,000
																									1—	10,000
																									1—	4,000
18	100,000	34·7	303,670,040	76,000	228,701 See footnote1	13,000	11·0	6·82	1·51	19,650	0·522	0·059	0·013	0·594	0·002	0·011	0·012	0·006	—	0·031	0·625	No	10—	1,263	4—	31,250*
																							4—	1,384		
64	95,000	8·96 See footnote2	74,580,700	58,000	81,127	13,000	10·4	5·52	2·18	28,260	0·597	0·141	0·041	0·779	0·019	0·072	0·017	0·004	0·004	0·115	0·894	Yes	11— with 9,400 sq. ft. economisers	1,140	3—	20,000
																									1—	35,000
220	87,000	31·8	242,457,293	65,000	223,106	14,300	6·0	6·30	1·84	26,300	0·587	0·042	0·013	0·641	0·004	0·016	0·016	0·009	0·001	0·046	0·687	—	20—	600	3—	9,000*
																							7—	1,000	2—	5,000*
																							4—	525	2—	15,000*
																							1—	1,000	1—	20,000*
7	72,000	16·9	106,641,022	40,300	95,694	14,698	5·9	5·76	1·80	26,400	0·618	0·092	0·020	0·730	0·006	0·047	0·028	0·028	0·008	0·089	0·819	—	16—	600	3—	4,000
																							8—	755	1—	10,000
																									2—	15,000
																									1—	20,000
115	48,000	23·2	181,657,165	41,700	113,772 See footnote3	13,000	14·0	4·68	—	25,800	0·544	0·150	0·024	0·718	—	—	—	—	—	0·123	0·841	No	14—	900	2—	15,000
																									1—	5,000
					374,631 barrel oil	18,000		1·22 per barrel	—																1—	4,000
																									3—	2,500
																									1—	1,500†
53	60,000	58·2	305,867,600	62,000	243,089	13,150	10·1	3·96	1·59	20,900	0·330	0·066	0·034	0·430	0·007	0·022	0·007	0·003	0·001	0·040	0·470	Yes	7—	2,087	1—	60,000
84	60,000	40·8	214,351,541	48,400	212,415	10,733	—	4·86	1·98	21,250	0·537	0·059	0·022	0·618	0·001	0·020	0·001	0·005	0·008	0·034	0·652	—	8—	1,388	3—	20,000
12	55,000	7·6	36,664,720	24,500	43,493	13,650	9·0	8·59	2·37	32,350	1·019	0·222	0·039	1·280	0·027	0·092	0·011	0·018	0·011	0·159	1·439	—	12—	700	1—	25,000*
																							See footnote4		1—	20,000*
																									2—	5,000*
186	53,000	28·7	133,200,300	28,200	149,171	10,457	16·1	5·30	2·24	23,400	0·596	0·052	0·018	0·666	0·007	0·048	0·006	0·006	0·005	0·071	0·737	—	7—	550	2—	3,750
																							2—	450	1—	5,000
																							8—	500	1—	4,000
																							1—	1,500	1—	1,500
																									1—	15,000
																									1—	20,000
187	50,000	57·5	217,351,608	50,650	344,414	10,120	20·0	2·20	3·17	32,105	0·340	0·091	0·047	0·478	0·018	0·072	0·049	0·032	0·045	0·216	0·694	No	8—	1,043	3—	10,000
																							6—	1,179	1—	20,000
																									See footnote5	
241	48,250	27·1	114,681,040	34,000	128,180	12,263	13·0	3·90	2·30	28,200	0·436	0·073	0·032	0·541	0·007	0·050	0·035	0·009	0·005	0·105	0·646	No	1—	520	2—	3,500
																							10—	512	1—	6,250
																							6—	1,000	1—	10,000
																									2—	12,500
13	45,000	36·3	143,075,400	37,500	127,221	12,770	11·3	4·56	1·78	22,720	0·443	0·050	0·026	0·519	0·002	0·043	0·028	0·004	0·001	0·078	0·597	No	6—	1,373	2—	12,500
																									1—	20,000
71	44,500	15·8	61,577,400 See footnote6	28,115	bit. 60,129 anthr. 10,685	14,270 12,000	8·1 18·16	7·34 4·55	—	32,000	0·638	0·127	0·078	0·843	0·021	0·044	—	0·025	0·014	0·103	0·946	—	6—	600	2—	20,000*
																							2—	700	2—	7,800*
																							6—	1,250		
184	40,000	58·0	202,908,075	47,000	163,866 See footnote7	11,961	—	4·94	1·61	19,200	0·394	0·067	0·008	0·469	0·002	0·034	0·003	0·002	—	0·041	0·510	—	8—	1,306	2—	20,000
57	40,000	20·8	72,678,690	18,200	57,963	14,107	13·6	3·22	1·60	22,550	0·283	0·098	0·006	0·387	0·006	0·040	0·014	0·006	0·007	0·073	0·460	No	4—	1,425	1—	20,000
																									2—	10,000
234	37,500	30·5	100,420,900	—	41,521 2,164,191,000 cu. ft. gas See footnote8	10,700	15·0	3·91	—	—	0·711	0·092	0·036	0·838	—	0·038	—	0·047	—	0·085	0·923	Yes	32—	500	1—	2,000‡
																									1—	2,000‖
																									2—	7,500
																									1—	6,000
																									1—	12,500
211	35,900	19·4	61,170,000	21,000	86,187	9,338	17·0	4·19	2·82	26,300	0·590	0·101	0·007	0·698	0·009	0·029	0·008	0·034	0·004	0·084	0·782	Yes	11—	503	1—	16,000
																							4—	577	1—	10,500
																							3—	1,003	1—	6,400
																									1—	3,000
85	33,000	34·8	99,418,700	22,900	114,547	14,500	6·8	6·10	2·30	33,350	0·703	0·111	0·012	0·827	0·001	0·022	0·016	0·008	0·003	0·048	0·875	—	16—	512	3—	10,000
																									1—	3,000
133	30,000	24·3	26,602,855	15,700	38,465 See footnote9	10,921	—	4·11	2·89	31,600	0·594	0·211	0·053	0·857	0·005	0·076	0·006	0·003	0·003	0·092	0·949	No	4—	1,345	2—	15,000
251	24,000	22·0	32,642,600	17,000	59,685	—	—	4·23	3·66	—	0·877	0·265	0·028	1·170	0·042	0·107	0·035	0·028	—	0·212	1·382	Yes	22—	400	1—	10,000
																							2—	1,000	1—	7,500
																									1—	4,000
																									1—	2,500

1. Burns natural gas and coal; coal given is equivalent coal; actual coal burned is 78,586 tons. 2. Auxiliary to hydro-power. 3. Burns coal and oil. 4. Boiler plant equivalent to 36,000 kw. 5. Turbine rated at 20,000 kw. added 11/17/21; six boilers 5/27/21. 6. Energy purchased, 9,297,600 kw.-hr. not included. 7. Burns powdered fuel. 8. Burns natural gas and coal. 9. Five months' operation; first turbine and two boilers started 10/16/21; second turbine and two boilers put in service 10/18/22.
* K.V.A. † Engine-driven direct-current generator. ‡ Compound Corliss. ‖ Mixed pressure turbine.

TABLE II.—PRODUCTION COSTS OF A 1,500-H.P. DIESEL STATION.

	Jan. 1–Dec. 31, 1919.	Sept. 1–Dec. 31, 1916.
Engine hours	24,047	—
Gross kw.-hour	7,580,130	—
Net kw.-hour	7,507,940	1,565,000
Station factor	99	51
Fuel oil, lb.	4,988,120	1,490,720
Fuel oil per kw.-hour, lb.... ...	0·657	0·672
B.Th.U. per kw.-hour	12,700	13,100
Labour per kw.-hour, mills ...	1·577	1·44
Fuel per kw.-hour, mills	3·130	3·07
Water per kw.-hour, mills ...	0·0503	0·09
Lubricating oil per kw.-hour, mills	0·1748	0·04
Miscellaneous supplies per kw.-hour, mills	0·235	0·10
Building repairs per kw.-hour, mills	0·0945	0·05
Engine repairs per kw.-hour, mills	0·51	0·04
Auxiliary repairs per kw-hour, mills	0·0103	0·15
Electrical equipment repairs per kw.-hour, mills	0·0873	
Miscellaneous repairs per kw.-hour, mills	0·0167	
Total production cost, mills per kw.-hour	5·99	4·98

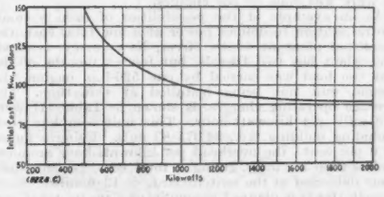


FIG. 4. INSTALLATION COST OF DIESEL PLANTS

charged with 6 per cent. interest, 2 per cent. taxes and insurance, and 5 per cent. obsolescence, a total of 13 per cent., the Diesel central station should likewise be charged 6 per cent. interest and 2 per cent. taxes and insurance, but the depreciation on a basis of compounding at 6 per cent., with a life of twenty-five years, would be slightly under 2 per cent., making a total of but 10 per cent. overhead. It would, therefore, appear that the oil engine plant has a decided advantage in the overhead that should properly be assessed against it, for the investment costs are about equal.

Comparative Operating Expenses of Diesel and Coal-Burning Central Stations.—Turning to a comparison of operating expenses, it must be conceded with frankness that only estimates are possible in respect to large Diesel plants. If it be granted that records of small oil engine stations bear some relation to the results to be expected from plants of 20,000 kw. capacity, it will be found that the Diesel compares very favourably with the largest steam installation. In *Electrical World*, June 2, 1923, appeared a compilation of the operating costs of 45 coal-burning central stations, the first page of which is reproduced as Table 1. It will be noticed that the largest plant reporting had a total operating cost per kilowatt-hour of 0·661 cent., and that the lowest, with a coal cost of 3·96 dols. per ton, had a total of 0·47 cent.

A Diesel station of as low a capacity as 2,000 kw. and with a load factor of 50 per cent. will deliver a

TABLE III.—PRODUCTION COSTS OF THE MUNICIPAL PLANT OF SOUTH RIVER, N.J.

Month, 1923.	Hours Possible.	Hours Operation.	Time Factor.	Kw.-hr. Output at Switchboard	Fuel Oil Consumed.	Kw.-hr. per Gallon.	Average Hourly Load.	Average Hourly Load Factor.
					gallon.		kw.	
January	744	538	0·722	133,740	13,600	9·83	249	0·743
February	672	563	0·838	155,340	15,180	10·23	275·8	0·823
March	744	566	0·761	157,760	15,160	10·50	278·7	0·832
April	720	357	0·496	67,140	7,520	8·92	188	0·561
May	744	670	0·900	119,410	13,960	8·55	178·2	0·532
June	720	650	0·903	135,590	14,880	9·11	208·5	0·625
Total	4,344	3,343		768,980	80,300			
Average			0·770			9·57	230	0·686

Month, 1923.	Fuel Oil.	Lubricating Oil.	Attendance.	Maintenance.	Total Operating Cost.	Total Cost per kw.-hr. at Switchboard.
	$	$	$	$	$	$
January	748·00	112·50	323·00	—	1,183·50	0·00884
February	834·90	117·00	323·00	—	1,274·90	0·00820
March	833·80	120·00	323·00	91·72	1,368·52	0·00867
April	413·60	74·50	323·00	4·81	815·91	0·01215
May	767·80	141·00	323·00	—	1,231·80	0·01031
June	818·40	135·00	323·00	1·73	1,278·13	0·00942
Total	4,416·50	700·00	1,938·00	98·26	7,152·76	—
Average	—	—	—	—	—	0·00930

SUMMARY OF OPERATING COSTS PER KILOWATT-HOUR.

	$
Fuel oil	0·00575
Lubricating oil	0·00091
Attendance	0·00252
Maintenance	0·00012
Total per kilowatt-hour	0·00930

kilowatt-hour at an expenditure of less than 0·8 lb. of fuel. The amount of labour will be less than in a steam plant, since all boiler-room labour is eliminated. In a 6-unit 20,000-kw. plant, six men per shift is more than ample. The lubricating oil consumption will be under 1 gallon per 3,000 kw.-hour, while the water consumption at 25 cents per 1,000 gallons, assuming an evaporation loss of 5 per cent., will be less than 0·002 cent. per kilowatt-hour. The probable operating charges in mills per kilowatt-hour will be approximately as follows:

Fuel (4 cents per gal.)	Labour.	Lubricating oil.	Water.	Supplies.	Total mills per kw.-hr.
3·419	1·00	0·08	0·0017	1·05	4·507

This total may seem astonishingly low to many, but it will be observed that the large item is fuel, and by using cheaper fuel procurable at 3 cents per gallon, the total becomes 3·652 mills per kilowatt-hour. It has been stated that the fuel consumption of Diesels is fairly constant regardless of the size, consequently this value can be checked by results in smaller plants, data on which will be given later. If it be conceded that the tabulation is conservative, then the statement that the road to economy in power generation is through decentralisation rather than through the construction of a few immense steam plants will appear to possess a certain merit.

That the estimate given is not misleading is proved by known results in existing plants. For example, the cost of operation in one 1,500-h.p. plant which was placed in operation in 1915 is shown in Table II. It will be observed that the operating costs in 1916 were 4·98 mills, or, eliminating the engine maintenance, 4·94 mills. In 1919 the costs were 5·99 mills per kilowatt-hour. In 1921 the costs were 12·7 mills but the maintenance of the engines amounted to 4·45 mills, leaving 8·25 mills for operating expenses. However, the fuel cost over 5·3 cents per gallon, while during this time oil suitable for these engines was available at 3½ cents. The item that is high is maintenance. This, as the owners acknowledge, is due to failure to keep the plant in condition during early years, when practically no work was done on the engines.

As an example of the possibilities of even a small central station to deliver power at a low total cost, the municipal plant at South River, New Jersey, is cited. This plant has two Diesels, but for six months of the test the load was carried by one 520-h.p. engine, the second unit not being installed at this time. The average operating charges as shown in Table III were 9·3 mills per kilowatt-hour. This unit complete cost, including building, &c., $4,375·83 dols. Using a factor of 9 per cent., the overhead per kilowatt-hour amounts to less than 3·2 mills, giving a total cost, per kilowatt-hour delivered at the switchboard, of 12·6 mills. Even though this is a plant of insignificant size, its total cost per kilowatt-hour is far below the generating costs of most of the steam plants shown in Table I. Attention is called to the labour item of 2·52 mills per kilowatt-hour. The actual labour is no less than that required in a plant of twice the capacity. For this reason the larger plants should show a large reduction in this item.

(To be continued.)

ELECTRICITY WORKS IN DENMARK.—According to a report recently published by the Danish Statistical Department the total number of electricity works in Denmark is 496, plus a number of small plants erected for individual farms or industrial undertakings.

CATALOGUES.

Aeroplanes.—Messrs. George Parnall and Co., Bristol, have sent us an interesting catalogue illustrating and describing their light single-seater aeroplane for sportsmen or for training pilots and several other aeroplanes for service use.

Electric Feeder Pillars.—A catalogue of electric feeder pillars built up in units, any one of which can be withdrawn without interfering with the other, is to hand from the General Electric Company, Limited, Kingsway, London, W.C.2.

Omnibus Bodies.—A folder illustrating several designs of two-deck and single-deck omnibus bodies is to hand from the Brush Electrical Engineering Company, Limited, Loughborough, who carried out several large contracts last year for this class of work.

Reduction Gears.—A catalogue of reduction gears issued by the H.R. Gear Company, Limited, 20, Conduit-street, London, W.1, shows a number of boxed units with driver and driven shafts projecting in line or at right angles. The gears are of the worm type, and are specially suitable for very large reduction ratios. Dimensions and prices are stated.

Pulverised Coal.—A large amount of useful information on the subject of pulverised coal firing is given in some catalogues we have received from the Fuller-Lehigh Company, Fullerton, Pa., U.S.A. These include a 32-pp. catalogue of machinery for preparing and applying coal dust fuel in boiler firing, a 24 pp. pamphlet, which covers much the same ground in a less technical style and a 6-page folder describing the conveying system for coal dust.

Laboratory Apparatus.—Messrs. A. Gallenkamp and Co., Limited, 21, Sun-street, Finsbury-square, London, E.C. 2, have sent us Part II of their catalogue, and forming the seventh edition of "Apparatus for Industrial Research." The catalogue is a bound volume of 280 pp., closely filled with illustrations, descriptive text and tables of dimensions, prices, &c. The instruments, machines and utensils for chemical, optical and other measuring, testing and analytical operations are very fully represented.

Motor Vehicle Brakes.—The now generally recognised need for more effective emergency brakes for commercial vehicles, omnibuses, fire engines and other heavy motor cars lends interest to a catalogue issued by the Westinghouse Brake and Saxby Signal Company, Limited, 82, York-road, King's Cross, London, N. 1. The brake described is actuated by compressed air or gas, thus relieving the driver from physical strain and giving complete and effective control of the application of the retarding force.

Electric Railway Motors.—Catalogues of a 50-ton slow-speed locomotive of high-continuous rating, a railway motor for heavy freight service and a railway motor for high-speed service have been received from the Westinghouse Electrical Manufacturing Company, Pittsburg, Pa., U.S.A., whose London office is at 2, Norfolk-street, Strand, W.C. 2. In all cases a performance chart is given with curves of tractive effort, speed, efficiency, &c., and tabulated particulars of hourly, continuous and maximum capacities, as well as some general notes.

Chains.—A catalogue of chains, slings, couplings, and drop forgings of various chain connections, especially suited for colliery plant, comes from Weldless Chains, Limited, Gartsherrie, Coatbridge. These chains are made without welds by rolling them from bars of cruciform section by the process explained on page 802 of our issue of June 29 last, and the drop forgings listed include rings, hooks, shackles, eye and stem pieces, &c. Some useful notes on the prevention of accidents and the periodical annealing of chains are included in the catalogue.

Cement-Making Machinery.—The wide range of machinery used in the manufacture of cement is dealt with in a catalogue received from Messrs. William Johnson and Sons, Limited, Armley, Leeds. The plant dealt with includes crushing, drying, washing and mixing machines; tube, compound and ball mills and clinker grinding plant; kilns erected in batteries; coal-grinding machines for reducing the coal to the fineness required for firing rotary kilns; and other machinery. In the last thirty years great advances have been made in this class of plant to meet the more exacting requirements of modern cement manufacture.

Coal Cutter.—The Hardy Patent Pick Company, Limited, Sheffield, have sent us a pamphlet giving the results of a test made on one of their "Hardiax" radial percussive coal cutters in bord and pillar work at a Durham colliery. In these tests one operator in the course of a six-hour shift, time being reckoned from bank to bank, cut eight bords containing 499 sq. ft. in all. The actual cutting speed averaged 139 sq. ft. per hour for all the eight places, and the maximum speed attained was 180 sq. ft. per hour. These figures, the makers believe, constitute a record for radial percussive coal cutters in bord and pillar work.

General Engineering.—A catalogue containing 60 illustrated pages, recently to hand, conveys a good idea of the great extent and varied character of the business carried on by Messrs. Thomas W. Ward, Limited, from Sheffield, as a centre with very numerous branches inland and round the coast. Second-hand machinery of all kinds forms the basis of the firm's activities, but new machinery is also supplied and repairs and manufacturing work is also undertaken. They also supply new and scrap metals, coal, coke, structural and other steel work and mechanical equipment for contractors. Shipbreaking is another important feature of the firm's work.

Steel.—A reference book of steel containing a series of notes for the guidance of users of this material is to hand from Messrs. William Jessop and Sons, Limited, Brightside, Sheffield—one of the oldest steel manufacturing firms. The contents include some interesting particulars of the history of the firm, a summary of heat treatments, a table of tool and special steels with particulars of analyses and tests, a list of castings, forgings, stampings and materials for various steel products and a list of tool and structural steels with notes on the special purposes for which each is best suited. Engineers will find this publication one of the most useful of its kind.

Derrick Cranes.—A catalogue of self-propelling steam derrick cranes, suitable for running on roads or rails, has reached us from the Brown Hoisting Machinery Company, Cleveland, Ohio, U.S.A. These cranes are fitted with booms ranging from 20 ft. to 40 ft. in length when arranged for road travelling, and from 25 ft. to 40 ft. in length when the crane is used on rails. The maximum lift is 18,000 lb. at short radius and 2,800 lb. at 40 ft. radius for the road type while the rail type crane will lift 4,200 lb. at the last-mentioned radius. The clam-shell type of bucket is used for handling all loose material, including coal. Numerous illustrations are included in the catalogue to show the various applications of the crane.

Tool Steel.—A revised edition of their catalogue of "intermediate" tool steels is to hand from Messrs. Edgar Allen and Co., Limited, Sheffield. New matter had been added relating to Maxchip steel for chisels, stainless steel and permanent magnet steel. All the steels dealt with in this catalogue are of an intermediate character, coming between carbon tool steels and high-speed tool steels, the object being to supply the most economical steel for any particular service. Heat treatment is dealt with, and other practical information is given for a range of tools including turning tools, drills, dies, taps, milling cutters, reamers, punches, snaps, thread rollers, chisels, coal cutter bits, &c. On all points the catalogue is of great practical interest.

Telegraphy and Telephony.—A handsomely printed, illustrated souvenir book in celebration of the fortieth anniversary of the foundation of their business has been issued by the Western Electric Company, Limited, Connaught House, Aldwych, London, W.C. 2, for presentation to their employees. Owing to the wide scope of the company's manufactures the record of their work contained in the souvenir amounts to a technical history of the development of telephony and telegraphy, both wired and wireless, with special descriptions of the essential parts of the mechanism and of accessory instruments such as those for reproducing public speeches in amplified form, so that they can be heard by immense audiences. The publication is one of the most interesting of its class that we have received.

DANISH TONNAGE.—The Statistical Department, says the Danish Foreign Office Journal, has recently issued its shipping register, according to which there were in the Danish Mercantile Marine on the 1st inst., of ships of all classes over 20 tons gross, a net register tonnage of 656,200, the gross tonnage being 1,054,600, as against 1,041,000 at the beginning of 1922 and 912,900 at the beginning of 1921. Although the steamships only numbered about one-third of the total (32·7 per cent.) their tonnage represented 74·7 of the whole; about four-fifths of them, aggregating 615,800 gross tons, were cargo steamers. The number of motor ships was 67, and their gross tonnage 129,224.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

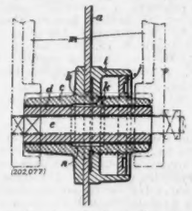
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AGRICULTURAL APPLIANCES.

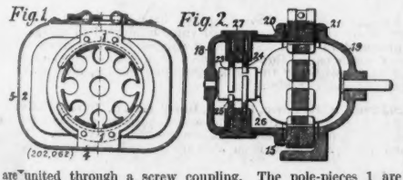
202,077. A. Challacombe, Grantham, and J. Lowson, Grantham, and Ruston and Hornsby, Limited, Lincoln. Disc Coulters. (1 *Fig.*) May 22, 1922.—According to the present invention, the bearing of a disc coulter for ploughs, drills, harrows and like agricultural implements is provided with a cup or receptacle *i* for grease, extending about or around the axis thereof. The grease is delivered preferably to the centre of the



bearing and is forced outwards from time to time as required to each end of the bush, so keeping the bearing free of grit. The disc coulter blade *a* is secured against a boss *c* by the annular grease cup *i* threaded on a portion *h* of the boss which revolves on a bush *d* held by a bolt *e* between the forked ends *m* of a support. A cover plate *j* screwed on the part *h* is rotated inwardly at intervals to force grease into the central annular channel *n* in the boss. (*Sealed*)

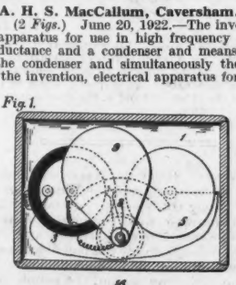
ELECTRICAL APPARATUS.

202,062. Evershed and Vignoles, Limited, Chiswick, London, and G. B. Rolfe, Chiswick, London. Magneto Electric Generators. (5 *Figs.*) May 17, 1922.—The invention relates to magneto electric generators. The field magnet system comprises pole pieces 1 and permanent magnets 2 arranged as a magnetic system analogous to the field magnet system of a "Manchester" type dynamo. The ends of the permanent magnets 2 contact on either side of the pole-pieces 1 with abutments formed by projections 4 on the pole pieces 1 and are maintained in this position by a band 5. The ends of the band 5



are united through a screw coupling. The pole-pieces 1 are associated in proper relation the one to the other by securing them to members 15 (see Fig. 2) of non-magnetic material. The members 15 are of ring form and arranged concentrically with the polar faces of the pole pieces 1. To support the armature, bearing brackets 18, 19 are provided: the bearing brackets are provided with recessed portions 20, 21, respectively adapted on assembly with the pole pieces 1 to engage with the ring-like members 15 aforesaid. The brushes 23, 24, 25 and 26 are carried in housings 27 mounted on the bearing bracket 18. (*Sealed.*)

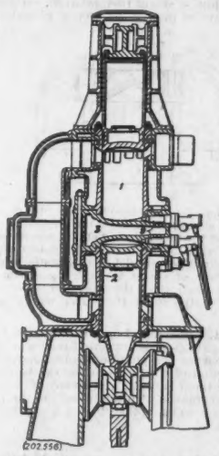
202,115. A. H. S. MacCallum, Caversham. Wireless Telegraphy. (2 *Figs.*) June 20, 1922.—The invention relates to electrical apparatus for use in high frequency circuits comprising an inductance and a condenser and means to vary the capacity of the condenser and simultaneously the inductance. According to the invention, electrical apparatus for use in high-



frequency circuits comprises an inductance, a conducting shading member movable relatively to the inductance and a second conducting member forming with the shading member a condenser. The inductance may be connected in parallel with the inductance, and may be varied simultaneously in the same direction for tuning purposes by moving the shading member. Referring to Fig. 1, the inductance 3 and the fixed member 5 of the condenser are mounted in recesses on the underside of a sheet 1 of insulating material, and the shading member 9 is secured to the spindle 8. In Fig. 2, the inductance 12 in the form of a solenoid and the fixed member of the condenser in the form of a metal tube 14 are mounted on an insulating carrier 13. The shading member 15 surrounds the tube 14 and the coil 12, and is adjustable in position by a handle member 16. (*Sealed.*)

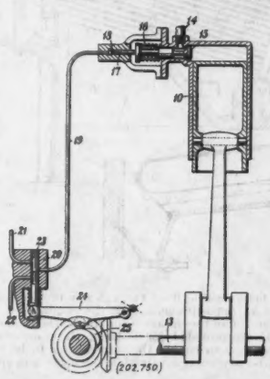
GAS ENGINES, PRODUCERS, HOLDERS, &c.

202,556. J. McCallum, Birkenhead. Internal-Combustion Engines. (2 *Figs.*) October 31, 1922.—The invention relates to internal-combustion engines of the two-stroke Diesel type in which a pair of co-axial cylinders is separated by a



diaphragm. According to the invention, the cylinders 1, 2 are separated by a single diaphragm 3 constituted by a double combustion head which takes the form of a water-jacketed casting and is fitted with Diesel fuel valves 9 for both cylinders. (*Accepted August* 29, 1923.)

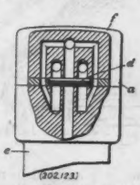
202,750. R. P. Doxford, Sunderland, and K. O. Keller, Sunderland. Internal-Combustion Engines. (1 *Fig.*) May 30, 1922.—The invention relates to compressed air inlet valves for internal-combustion engines. The invention relates to engines of the type in which the fuel is supplied to the cylinder under high pressure, and in which the fuel system is maintained under a steady pressure at all times. A compressed-air supply pipe 14 communicates with the interior of the cylinder 10 through a port controlled by a valve 15. A hydraulic piston 17 engages the valve so as to move it in its opening direction. The cylinder 18 of the piston 17 communicates by a pipe 19 with a controlling device 20 which comprises a valve chest having pipe-connections



19 as aforesaid, 21 to the high-pressure fuel oil system and 22 to exhaust, so that there is a conduit extending from the source of high-pressure fuel oil to the hydraulic piston, this conduit being in part constituted by the pipe 19, and being controlled by the device 20. Within the valve chest 20 there is a valve 23 constructed to open communication between the pipes 21, 19, or alternatively, between the pipes 22, 19. In the first case, high-pressure oil is admitted to the pipe 19 to move the piston 17 and thereby open the valve 15, and in the latter case, the pipe 19 is open to exhaust to relieve the pressure therein so that the spring 16 can close the valve 15. The valve 23 is operated by a rocking lever 24 actuated by a cam 25 and shaft 26 driven from the engine crankshaft 13. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

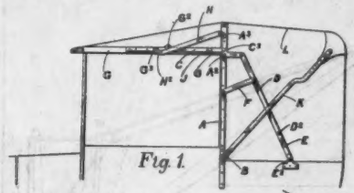
202,123. C. H. Stevens, High Wycombe. Pneumatic Hammers. (3 *Figs.*) June 27, 1922.—A pneumatic hammer made in accordance with the invention comprises a handle

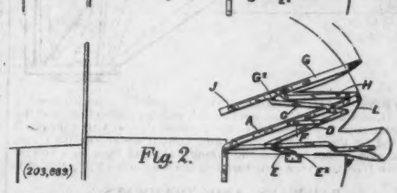


member *f* having a flat transverse face in which ports are formed, a cylinder member *e* also having a flat transverse face in which ports are formed and a single valve plate *a* provided with a recess carrying a valve consisting of a disc or flat plate *d*. The single valve carrying plate *a* is clamped between the opposing flat faces of the handle member *f* and cylinder member *e*. (*Sealed.*)

MOTOR ROAD VEHICLES.

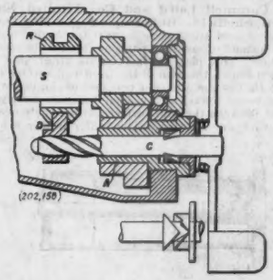
203,889. The Hillman Motor Car Company, Limited, Pinley, Coventry, and E. A. Green, Pinley, Coventry. Collapsible Hoods. (2 *Figs.*) September 4, 1922.—The invention relates to collapsible hoods for motor vehicles. The main pillar A is pivoted to the body at B and to it is pivoted at A^2 the forwardly and rearwardly extending link C which is cranked upwards slightly as shown at C^2. Pivoted to the rear end of the link C is a foldable strut D, E, which is pivoted to the body at E^2. The joint D^2 occurs at about one-fourth of the total length of the strut from the end E^2. F is a link which connects the strut D, E with the main pillar. The front bow G is hinged at G^2 to the link C in such manner that it can turn through substantially 180 deg., and the hinging is slightly offset upwardly so that when extended the bow G is in the same straight line as the link C, and when folded it lies somewhat to the side of it. From the upper end of a forwardly offset portion A^3 on the main pillar A, a tie link H extends to the bow to a position G^3. This tie link is





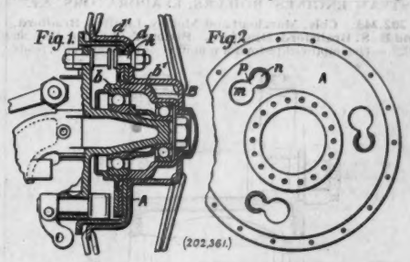
forwardly and upwardly offset at H^2, such offsetting being adapted to cause the links C and H to lie compactly parallel with one another when folded. At the rearward end of the bow G is a stop J which is adapted to engage the underside of the link C, thereby to limit its turning movement about the pivot G^2 when extended, and also to take the downward load upon its front part. Thus the framework when extended constitutes an exceedingly rigid structure, the front bow G being very strongly supported and collapse of the foldable strut D, E being prevented by the link F. Actually the system is locked by the bow G through the tie link H, and therefore the motion to collapse the framework is commenced by swinging the bow about its pivot G^2, when the whole linkwork closes up compactly and lies neatly in a horizontal position upon the body, the various parts terminating approximately at the same distance rearwardly of the vehicle and, relatively speaking, taking up but little space. (*Sealed.*)

202,158. Sir E. Jardine, Nottingham, E. Watchorn, West Bridgford, and I. Cohen, West Bridgford. Variable-Speed Gears. (5 *Figs.*) August 1, 1922.—The invention relates to controlling mechanism of variable speed gears of the countershaft type and, according to the invention, the lay shaft A is



utilised to carry a member C for operating the fork D which engages with the sliding dog clutch B or like member on the main shaft S. In the preferred arrangement, the lay shaft A is hollow, and the control shaft D is disposed in its hollow interior. (*Accepted August* 22, 1923.)

202,361. Sir H. Austin, Bromsgrove. Detachable Wheels. (4 *Figs.*) April 20, 1922.—The invention provides improved means of securing a detachable wheel in relation to the permanent hub. According to the invention, as applied to a wheel with a removable hub A, the latter is adapted to be put on over the fixed hub B and the former is provided with a flange

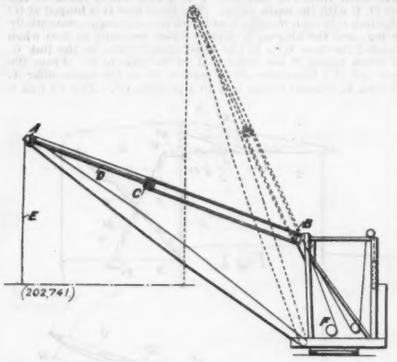


having holes *m*, *n* in pairs of different size and united by an opening *p*. The fixed hub is formed in two parts *b*, b^1 connected together by means of set screws passing through holes in flanges *d*, d^1 of the hub portions b^1, *b*, respectively. The flanges *d* and d^1 carry a set of studs *h*, each of which is provided with a nut. The holes *m* are of a diameter sufficient to allow the nuts

to pass right through. In putting the wheel in place, its removable hub is put on over the fixed hub *b* so that the nuts enter the holes *m*. The wheel is then given a slight turn in an anti-clockwise direction causing the studs to pass through the openings *p* and enter the holes *n*, the nuts are then tightened up securely. (*Accepted August 29, 1923.*)

LIFTING AND HAULING APPLIANCES.

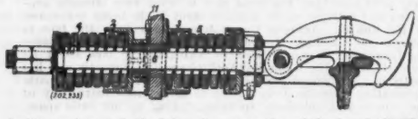
202,741. E. Griffiths, Whitley Bay, and Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-on-Tyne. Cranes. (1 *Fig.*) May 26, 1922.—The invention relates to cranes of the type in which means are provided for compensating for the change in height of the jib head due to luffing, so that during luffing the load may move on a plane approximately horizontal.



According to the invention, there is pivoted to the jib head a link D, such as a link commonly employed as a luffing link, and the hoisting rope E is reeved over the jib head sheave A to a sheave B carried by the crane structure and located above the jib pivot, back over a sheave C on the luffing link, and then to a second sheave B on the crane structure to a hoisting drum F. (*Sealed.*)

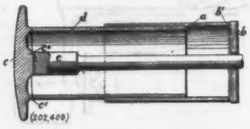
RAILWAYS AND TRAMWAYS.

202,233. J. Mitchell, Putney, and J. C. G. Cossey, Golders Green, London. Couplings. (3 *Figs.*) February 19, 1923.—The invention relates to means for preventing the rotation of the draw-bar of a central coupling and more particularly to devices for this purpose in which the draw-bar 1 is surrounded by a ferrule 6 inserted in the casings 2, 3 containing the draw and



buffing springs 4, 5, the internal cross-section of the ferrule 6 and the corresponding cross-section of the draw-bar 1 being formed to prevent relative rotation between the ferrule and the draw-bar. According to the invention, a flange 11 is provided on the external surface of the ferrule 6 which engages a recess of corresponding form in the casing 2. (*Sealed.*)

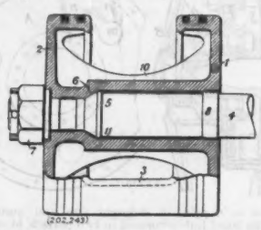
202,409. Cammell Laird and Co., Limited, Sheffield, and L. C. Ord, Sheffield. Buffers. (4 *Figs.*) May 18, 1922.—The buffer case *a* and back plate *b*, also the buffer head *c* and plunger *d*, are formed of separate parts adapted to be electrically welded together. The plate *b* has on its front side a short cylindrical extension *b*1, the area of the front end surface of which corresponds to that of the adjacent rear end of the buffer case *a*, the two parts being electrically welded together by passing an electric current between the said surfaces whilst these are held in close contact with one another. The buffer head *c* is provided



on its inner side with a short circular extension *c*1 having its annular end surface equal in area to that of the adjacent end of the buffer plunger *d* to which it is to be united, and also with a short solid central stub *c*2 having its end surface of the same area as the adjacent end of the central rod or spindle *e* to be united thereto. The several parts are assembled and held against each other and an electric current passed simultaneously through both pairs of abutting surfaces, or the current may be passed through each pair of abutting surfaces separately, commencing say with the inner pair. (*Sealed.*)

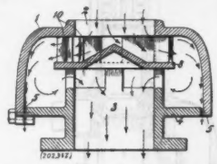
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

202,243. Cole, Marchent and Morley, Limited, Bradford, and R. S. Brailsford, Bradford. Pistons. (2 *Figs.*) May 20, 1922.—The improved piston for a uniflow or other engine is made



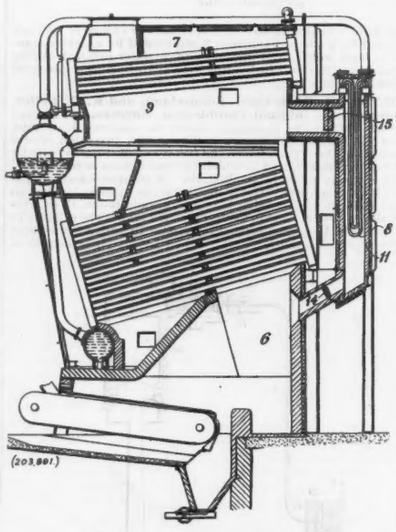
up of two end portions 1, 2 united by a skirt portion 3 integral with the portions 1, 2. The piston is mounted on the piston rod 4 in that a cone part 5 on the piston rod 4 fits within a similar part 6 of the piston 1, and is secured thereon by means of a nut 7. The piston rod is free along the greater part of its length and has a collar 8 at its opposite end bearing within a turned out part of the portion 1 of the piston and having a feather key slidably engaging the portion 1. Strengthening webs 10 are provided uniting the two portions 1, 2 and the boss 11 of the piston. (*Sealed.*)

202,387. R. S. Portham, St. John's Wood, and A. E. Tompkins, C.B.E., Little Brookley, Brockenhurst. Steam Dryers. (1 *Fig.*) May 16, 1922. A steam dryer in accordance with this invention has a water separating chamber 1 in which the steam is given high velocity rotary flow to separate out the contained water by centrifugal force and the steam inlet 2 and steam inlet 3 being separated from one another by a partition 8 to prevent direct flow of steam therebetween. Guide deflecting passages 10 are provided in or in connection with the partition 8



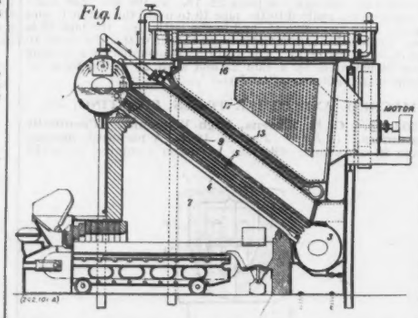
to impart high velocity rotary flow to the steam as it enters the water separating chamber. The water discharge outlet 5 is situated at or about the greatest diameter of the water separating chamber 1 on the side of the partition remote from the steam inlet, and is in a direction parallel or substantially parallel with the direction of flow of steam through the steam outlet and provides an exit through which the separated water is discharged tangential to the periphery of the water separating chamber. (*Sealed.*)

203,801. A. H. Spearing, London. Steam Generators. (1 *Fig.*) June 16, 1922.—The invention relates to that type of boiler plant wherein for the purpose of obtaining a high degree of superheat a portion of the furnace gases can be caused to pass to a superheater without having given up any of its heat in steam generation. In accordance with the invention, the plant has an economiser 7 in the boiler uptake 9 and a superheater 8 in a

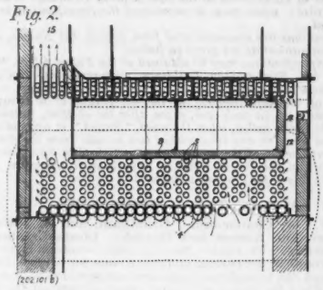


compartment 11 accessible from the exterior of the boiler and communicating at opposite ends with the combustion space 6 and with the portion of the uptake 9 containing the economiser 7. Dampers 14, 15 are provided for isolating the compartment 11 from the spaces 6, 9 to enable the superheater to be removed for inspection and renewal or repair while the boiler is in operation. (*Sealed.*)

202,101. R. Royds, Broughty Ferry, Dundee. Water-Tube Boilers. (3 *Figs.*) June 8, 1922.—Water tube boilers in which upper and lower rows of tubes connecting upper and lower headers or drums form impenetrable walls, are provided with tile baffles behind the upper rear row with openings whereby one



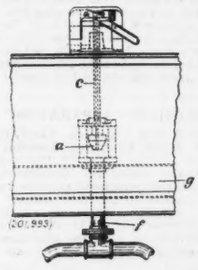
portion of the gases pass from one end to the superheater and then join the remaining portion from the other end, the combined gases then passing to the feed-water heater or air heater or both. The steam and water drums 1, 3 are connected by tubes 5. Between the tubes 5 and the furnace chamber 7 an impenetrable wall is formed by tubes 4, which are of larger diameter than the tubes 5, touching each other for the greater part of their length. An opening for the passage of the products of combustion may be at each end of the impenetrable wall adjacent to the headers or an opening may be arranged at the middle part of the wall. Instead of the tubes 4 touching, the spaces may be packed with refractory material. Behind the rear row of tubes 5 the tile



baffle plates 9 are placed and are disposed so as to leave open ends through which the products of combustion pass, one portion proceeding by the duct 12 through the superheater 13 to the duct 15 on its way to the chimney. The other portion of the gases passes through the duct 15. The two portions of gases meet and flow through the feed-water heater 16 and air heater 17 to the chimney flue. A damper 18 controls the flow of gases through the superheater. (*Sealed.*)

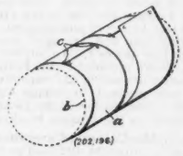
MISCELLANEOUS.

201,993. Thomas Coleman and Sons, Limited, Derby, and A. Coleman, Derby. Tar Spraying Machines. (4 *Figs.*) May 3, 1922.—The invention relates to valves for tar, bitumen and like heaters and spraying machines. The invention essentially comprises an improved valve for tar, bitumen and like heaters and sprayers in which a tubular spindle *c* open to the atmosphere



at its upper end, and having suitable operating means, carries at its lower end a hollow conical valve *a* adapted to engage a complementary valve seating at the upper end of a discharge pipe *f* which passes through a flue *g* from the furnace or other heating means below the tank containing the tar, bitumen or other material. (*Sealed.*)

202,196. J. H. Lowe, Basted, Boro' Green. Dandy Rolls. (2 *Figs.*) October 7, 1922.—The invention relates to detachable and interchangeable water-mark devices for dandy rolls. The water mark is mounted on a strap or band *a* of wire gauze



adapted to be wrapped around the surface of the dandy roll *b*, and is detachably and interchangeably fastened by its back to the surface of the roll by press buttons or equivalent two-part fasteners *c*. The fasteners *c* are disposed along or close to the meeting edges of the strap or band *a*, the meeting edges of which do not overlap. (*Sealed.*)

THE RAND WATER SUPPLY.—It is exceedingly fortunate not only for Johannesburg and the Witwatersrand, but for various towns along the Vaal River, that the great Rand Water Board barrage was completed a few months ago, says *The South African Mining and Engineering Journal*. Had it not been for the fact that this wonderful engineering undertaking had been storing quantities of water since the last rainy season, the people of the Rand and of various small towns and villages in the Southern Transvaal and the Northern Orange Free State would have experienced a great shortage of water, as a result of the severe and prevailing drought. The barrage is approximately 23 miles down river from Vereeniging. It has been completed at a cost of 1,500,000*l.* and the quantity of water stored is approximately 13,633,000,000 gallons. The barrage took six years to complete. The mines contributed 46½ per cent. of the Rand Water Board's various undertakings, which cost in the neighbourhood of 5,000,000*l.* The gold mines are the most vilified institutions of South Africa, but, as will be seen from the above, they contributed nearly one-half of the colossal sum of money for completing the Rand Water Board's scheme, a scheme which has proved a godsend to the whole country.